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MR. A. E. OUTERBRIDGE, JR., President in the chair.

THE PRACTICAL ASPECT OF PRESENT COMMERCIAL METHODS OF TESTING IRON AND STEEL.

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Before entering on the discussion of the subject of the paper I have the honor to read to you this evening, I beg permission to state the reasons why the subject of testing iron and steel deserves general attention. Just now we appear to be in a transitory state concerning not only our social and political but our commercial and industrial organization. Among other things, we are learning somewhat painfully that the popular cry of our inexhaustible resources, which for years has been dinned into our ears, has been leading us into habits of extravagances which, to unlearn, will take another generation.

At the same time, it cannot be denied that the lavish use of our national resources has been instrumental in promoting our rapid development and in the attainment of our present commanding commercial and industrial position among the nations of the world.

The subject of small economies has become a favored study with engineers and managers of works at the present time, when financial success depends largely on the ingenuity displayed in the perfection of economic methods of production and management.

When it is found necessary for the manager of a furnace to expend $40,000 for such improvements as will enable him to save 30 cents on the cost of producing a ton of pig iron; when the design of a heating furnace, promising the saving of 20 cents' worth of coal per ton of output, is anxiously studied by the manager; when the prices per pound of steel sold are calculated to the fourth decimal of a cent, and the saving of a hoop or two less on the barrels for shipping may represent all the profits on the investment in a year of depression, and when the increasing volume of available capital, with a consequent decrease of interest on the capital invested, compel the constructing engineer to provide for increased efficiency at a decreased cost, then we can readily perceive why the question of less quantity combined with better quality of the materials of construction has created a demand for means and methods to determine the most suitable qualities of these materials for a given purpose.

Thus the economic necessity of using the least permissible quantity of a material of approved quality has created an increasing demand for more or less elaborate systems of testing, inspecting and analyzing materials of construction. And since the results of the judicious application of the details of a system of testing involves questions of dollars and cents, success or failure, reputation or disgrace, of safety to life and limb, of freedom from anxiety and worry of various kinds, we may deem the consideration of the practical aspect of present methods of testing a question of economic value, a question of dollars and cents to the investor, to the director of a railroad, a

steamship line, or the stockholder of any concern, just as much as the profitable renting of a "skyscraper," of carrying passengers and freight, is a question of dollars and cents, the only difference being that the "skyscraper," the car or ship, carrying freight or passengers, is the end itself, while the testing of the materials used in building the "skyscraper," the car or ship, to make them useful as an interest-bearing investment, is a means to the end.

The measure of the value of a commodity is the proportional amount it takes to buy with it a given quantity of the necessaries of life; or, conversely, how much we can buy of the necessaries of life with a given amount of a commodity or its equivalent. If the commodity is worth much we get much, if it is worth little we get little. Similarily, the measure of the practical value of methods of testing iron and steel is the amount of knowledge we possess of the properties and qualities of these metals.

In other words, if we know much about the behavior of iron and steel under strain, our methods of testing will be the proper ones, and we will thereby obtain, or buy with that large amount of knowledge, if you please, a maximum of security, of safety, of reputation, of freedom from danger, anxiety and worry, of financial and social success for the investor and engineer. On the contrary, if our knowledge in this line of pursuit is inferior and defective, our methods of testing will be inferior and defective, and we can buy but a minimum of safety and success, with consequent loss through avoidable repairs, renewals, the use of more metal than is necessary, or inferior metal, and all this implies. Thus we perceive how proper methods of testing may become of high commercial value, a marketable commodity, as it were, of the knowledge we possess of the properties of iron and steel and the financially successful application of these properties.

Unfortunately, the effects of the work of proper or improper methods of testing are not so readily seen, demonstrable or calculable, as the correctness or usefulness of the structure can be measured, of which our work of testing is an essential part.

Let us examine for a moment what we are doing when we test a piece of iron or steel.

Testing will only then have a practical, that is, a commercially-economic value, if the method we use is in strict accord with the nature of the metal we test.

If the method is not in conformity with this essential requirement, which is the first principle in testing—that is to say, if by any method the metal which we test shows qualities different from those actually possessed by the metal we test—then our work of testing sinks to the level of an exhibition of the mechanical devices which we use for testing and of our skill in handling them.

All metals are viscous bodies, their viscosity being a matter of degree only and not of kind. Hence, the aim of testing must be to ascertain or measure the degree of viscosity possessed by the metal we test, and since it is the degree of viscosity which fits or unfits a metal to do a given work, it is obvious that methods of testing are of practical value in proportion to the degree of accuracy with which we ascertain the degree of viscosity of the metal we test and its natural behavior under strain.

Owing to the complexity of phenomena produced by the factors which tend to destroy a metallic structure, and to the inherent variableness of quality often found in the various members of a structure, or perchance in one of the members, and, owing to the want of opportunity by the engineer, which often prevents him, against his will, following up his observations to their sources by never-ending comparison with other similar metal, showing the same properties but varying qualities, there does at present not yet exist that uniformity of opinion concerning the properties and qualities of iron and steel, especially the latter, which is so desirable to produce the highest degree of economic value obtainable from a system of uniform methods of testing.

Of the various methods used at present to ascertain the physical qualities of iron and steel for structural purposes, the tensile test appears to be considered the most important and, therefore, the most widely used.

Although the value of the tensile test has been over-rated to a considerable extent, it is, nevertheless, an indispensable and most valuable guide in the realm of physical metallurgy. The engineer must have something tangible to base his calculations on, and this he can do only with the aid of the figures obtained in a tensile test.

Considering that a bending or nicking test of a whole bar shows its internal make-up as well and often better than the tensile test of a strip cut from that bar, it is within the limits of everyday experience to say that at present much time and money is spent for tensile testing of ordinary iron where a nicking test would answer the purpose and sometimes better.

The only advantage in such cases is that a tensile test is quite free from errors of judgment of the person making the test, while with a nicking test judgment and knowledge of methods of manufacture come into play if such a test is to be worth anything.

When making a tensile test, several different stages or phenomena attract our attention as the test proceeds.

In commercial testing these phenomena are defined as elastic limit, ultimate strength, per cent. of elongation, and per cent of contraction or reduction of area.

The elasticity of iron and steel is a complex function of the viscosity of the metal as a whole, the hardness of the individual crystal or fiber and the cohesive force by which these crystals or fibers are held together.

It is conceivable that the first strain applied brings the crystals or fibers into closer contact. If then the strain is released before sliding of the crystals and their deformation begins, they return or spring back to their original position, this action constituting the elasticity of the metals. If the strain is sufficient to produce sliding and deformation and the strain is released, the crystals will return or spring back only partly, while part of the deformation remains as permanent set. If now the strain continues without stopping, a point is reached where the viscosity of the metal comes into play.

At that point the metal begins to flow visibly, and flows so fast that, for a moment, it cannot hold up the weight or load

it had carried thus far. This point is indicated on the testing machine by the dropping of the scale-beam. If now the load is released there is a recoil as before, but it is very small, while the permanent set may be all the way from $\frac{8}{100}$ to $\frac{20}{100}$ of an inch.

After the drop of the beam the metal goes to destruction more or less rapidly.

Now it is this point when the beam drops which is called and assumed to be the elastic limit. Engineers and their inspectors use this drop of the beam in commercial testing almost exclusively, and of course the mills do not object as long as the consumer is satisfied.

In this illustration (*Fig. 1*) we can easily perceive the characteristic structural arrangement of a piece of steel.

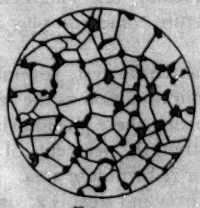

FIG. 1.

There are variations in size and form of structure, of course, according to per cent. of chemical elements and mechanical treatment, but since the effects of stresses are probably the same on all kinds of structures, the structure in this piece of steel will do as well for an illustration as any other.

Considering that the hard crystals of steel are imbedded in a softer matrix, and that, generally speaking, the proportion of this matrix is greater in the softer grades of steel, which brings the hard crystals farther apart in soft steel than in hard steel, it does not seem to require a great deal of imagination to perceive that the first stresses applied will tend to close up the spaces between the crystals by bringing them closer together and compressing somewhat the softer matrix in which the crystals are imbedded or surrounded. On release of the

stress the compression on the matrix is removed, and if the stress has been below the limit of compressibility of the matrix, the crystals will return to their original positions without themselves suffering distortion.

The hardness and size and shape of the individual crystals, the proportion and plasticity of the matrix, with all the complexities of variables produced by work and heat in the steel or iron, probably are the causes which, by their action and reaction, produce that apparent irregularity observed in taking the elastic limit and to avoid which a short cut is taken across lots, and the first interval of stretch without increase of load is taken as the elastic limit, which is the point when the beam drops temporarily.

Since limit of elasticity means that point where, on release of the load, the material strained assumes its original form and

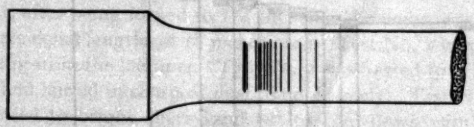

FIG. 2.

dimensions, it is obvious that a point where the permanent set measures from $\frac{3}{100}$ to $\frac{20}{100}$ of an inch cannot be the limit of elasticity.

Viscosity is active to change the form of the crystals. The cohesive force has yielded to the extraneous force and permitted the crystals to leave their original position and slide upon each other. The structure of the metal being thus in a disturbed and permanently distorted condition, it is self-deception to accept the drop of the beam as the limit of elasticity and as a basis of the engineers' calculations.

In this sketch (*Fig. 2*) the top line is the elastic limit or limit of proportionality. Each of the following lines represents 1,000 pounds of load applied while the test piece was under stress in the testing machine. The fifth line was made when the beam dropped, which means that in this case the so-called elastic limit is 5,000 pounds higher than the limit found with

the dividers. The changes taking place in the metal at the various stages of load and stretch are approximately illustrated in the diagram, *Fig. 3*.

Along the base line from *O* to *A* the stretch of the steel tested for each 1,000 pounds load is given in hundredths of an inch.

The actual stretch from load to load is magnified in the diagram for better illustration. The distances on the diagram between each succeeding load or vertical lines denotes that peculiar stage in the life of iron and steel where, after the elastic limit is passed, the metal stretches without increase of load. On the piece tested, the stretches between the point of elastic limit at 38,000 pounds and the drop of the beam at 42,000 pounds

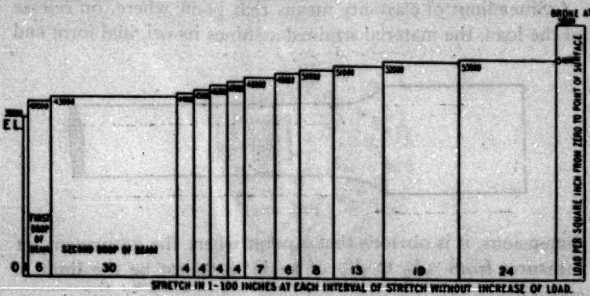

FIG. 3.

were so small, not quite $\frac{1}{100}$ of an inch in 1,000 pounds, that they are not given singly on the diagram, but are included in the space between 38,000 and 42,000 pounds. If we now analyze the diagram, we find the elastic limit at 38,000 pounds. From there to 42,000 pounds is a total stretch, as already stated, of a hundredth of an inch. At 42,000 pounds the beam dropped and the test-piece stretched $\frac{6}{100}$ of an inch until the beam rose again at 43,000 pounds; at that load it dropped again, and there was an interval of stretch without increase of load of fully $\frac{3}{100}$ of an inch before the beam rose to mark a load of 44,000 pounds. For the next four intervals the stretch is uniformly $\frac{4}{100}$ of an inch each, after which it increases rapidly for each 1,000

pounds load, until fracture took place at 58,600 pounds. One of the objections made against the present method of taking the elastic limit by the drop of the beam, or yield point, is that the drop is often not well defined, or that there are more than one drop, thus misleading the operator, who then, in order to make some showing on paper, gives whatever drop seems to him the most pronounced, or, worse still, what appears to him as a drop of the beam, producing results which are mere guess-work, a delusion and a snare. In the diagram, for instance, the first drop, being only one-fifth the duration of the second drop, is easily missed, and thus the engineer is persuaded to base his calculations on an elastic limit, at which the metal, if loaded to that point in actual service, would stretch and set permanently $1 + 6 + 30 = \frac{37}{100}$ of an inch.

Another very striking example illustrating the foregoing is shown in the following results of tests of a bar of axle steel: The bar, after being forged to 1⅛ inches in diameter, was cut into three equal lengths of 18 inches each. Test No. 1 was left as coming from the hammer. Test No. 2 was heated to bright cherry and buried in charcoal dust to cool slowly. Test No. 3 was heated to bright cherry and left to cool down with the furnace.

The elastic limit was taken with the dividers by the author while the man, operating the machine, and who is quite expert in that manner of work, noted the yield point.

COMPARATIVE RESULTS OF ELASTIC LIMIT (LIMIT OF PROPORTIONALITY) AND THE YIELD POINT AS OBTAINED BY THE DROP OF THE SCALE-BEAM.

Fig. IV.	Elastic Limit.		Yield Point.		Tensile Strength.	Elongation.
No.	Pounds per Square Inch.	Per Cent.	Pounds per Square Inch.	Per Cent.	Pounds per Square Inch.	Per Cent. in 8 Inches.
1	46,000	48·3	57,800	60·7	95,200	19·5
2	42,000	48·1	46,400	53·2	87,200	19
3	38,000	46·2	50,600	61·4	82,300	22

Analyses of these results show the elastic limit of No. 1 to be 48·3 per cent., and of Nos. 2 and 3, 48·1 and 46·2 per cent, respectively.

The elastic limit, as obtained by the drop of the beam or yield point, is 60·7 per cent. in No. 1, 53·2 per cent. in No. 2 and 61·4 per cent. in No. 3.

These figures appear all the more significant when we consider the well-known fact, liable of proof by any one who desires to do so, that annealing above 900° F. lowers the tensile strength, elastic limit and the yield point in proportion to the degree of heat applied.

In Bauschinger's "Mittheilungen," Heft XIII, page 26, it is said on this point:

"The effects of heating above that temperature (450° C.) and the subsequent slow or quick cooling consists in lowering the elastic limit and the yield point, the more so the higher the temperature was. However, the effects are greater on the former than on the latter."

Accordingly, we find the elastic limit in the annealed pieces Nos. 2 and 3 lower than No. 1. But, while the yield point of No. 2 is lower than of No. 1, it is higher in No. 3, although No. 3 is lower in tensile strength than No. 2 by 4,900 pounds. Thus we see that the method of taking the elastic limit with dividers, crude as it is, is still more reliable for revealing the true condition of the metal under test than the drop of the beam, which not only gives too high a value, but also gives results contrary to the accepted theories and practical experience.

If the elastic limit is a complex function of molecular movement of the individual crystals and a sliding upon each other of these crystals, then the smallest permanent set means a distorted structure of the metal from what it was originally, and if we apply from 3,000 to 12,000 pounds more load beyond the point where this distortion begins or up to the yield point, which is that point in iron and steel under stress where stretch momentarily increases faster than the load applied, then we clearly reach a point where a breaking up of the structure is near, or at least an entire change of structure takes place, due to the visible stretching of the metal. Hence, since a release of the load at the point of elastic limit means a complete restoration to its original condition of whatever distortion the

metal may have suffered at that point, while a continuation of the loading or stress beyond that point means not only a permanent but an increasing distortion in proportion to increase of load, and since at the point in testing where the beam drops temporarily because the metal is weakened momentarily to such an extent that it cannot carry the load, which means, if it means anything, an entire and radical change of structure at the yield point, a change in quality different from the quality the engineer had based his calculations on, therefore, the present method of testing, where the drop of the scale beam or yield point is assumed to be the limit of elasticity of iron and steel, is unscientific and unpractical, and a mistake, because at that point the structure or part of a structure has taken a considerable and visible permanent set, while what is meant by the elastic limit is a return to the original length, breadth or thickness of the metal on the release of the load. Beyond this point the engineer deals with new and unknown qualities of the metal.

Rather than to be satisfied with mere guesswork and self-deception, it would be better not to take the elastic limit at all.

Methods of manufacture have reached such a point of perfection in well-managed works that it is unnecessary to take the elastic limit of every test-piece. To take it occasionally with care, patience and accuracy is more rational than to be satisfied with what in many instances amounts to a mere guess. If the author has laid particular stress on this subject, it is because the limit of elasticity in iron and steel is the turning point from the known condition of the metal on which the engineer bases his calculations to the unknown condition of a changed structure about which the engineer knows nothing, knows nothing of its future behavior, and which change of structure we have reason to believe marks the beginning of the fatigue of a metal.

There is all the less excuse to be satisfied with a mere guess and a self-deception, since there are instruments in the market for determining the elastic limit, which, while they may not be perfect, are a great improvement over the data obtained by the drop of the beam. The ultimate strength is a reliable

measure of the power of a metal to resist stress, although the engineer does not consider his structure ever to be strained to the point of destruction. It has been proposed by some to stop testing at the elastic limit, by others to take the breaking load instead of the ultimate strength as the measure of value.

However, there are practical difficulties connected with the attempt to determine the breaking load accurately, and the proposition has been abandoned.

To accept the percentage of elongation in a given test section is a practical and reliable measure of the ductility of iron and steel. The elongation is the measure of the degree of plasticity which gives to a metal the power to yield under shock, to cushion the blow, as it were. Hence, the more plastic a metal the more it will stretch, and, therefore, this stretch, expressed in per cent. of elongation in a given section, is the measure of the degree of plasticity of the metal we test.

However, the flow of iron and steel under stress, due to these metals having the property of being viscous, is easily retarded by improper shape of test section, and the elongation, as a measure of the flow or plasticity of metals, will be of practical value only then if the test section gives free play to the viscous action of the metal under test. The 8-inch section, now generally used, fulfills this requirement better than any other section used in commercial testing, and, therefore, the present method of measuring elongation may be considered of practical value.

The same cannot be said of contraction or reduction of area as a measure of the commercial value of iron and steel. While contraction of area is valuable to the expert in the testing laboratory, in everyday commercial testing there is no time to study the various phenomena producing certain effects, but must have a direct exposition of the factors which tend to destroy a metallic structure. This contraction of area does not do.

In theory, contraction of area is supposed to represent the degree of plasticity of a metal by assuming that every particle of the metal under test is in prime condition to stretch and flow to its maximum capacity, until the extraneous force, trying

to tear the metal apart, is able to overcome the cohesive force with which the particles are held together. Wöhler, who has done so much to advance our theoretical knowledge of iron and steel, and who was the father of contraction as a measure of quality, based his earlier specifications on the above assumption by making tensile strength, plus per cent. of contraction of area, equal 100, 100 being the standard for quality, with a minimum allowance of 95. This assumption, however, presupposed an ideal metal, which we seldom get with the everyday production of masses of metal for commercial purposes.

Even with the exercise of proper skill and care there is no puddle ball or steel ingot having all its constituent elements distributed so uniformly as to leave no more of them in one place than in another, thus causing a difference in structure with a consequent difference in density, which in turn leads to an inequality of flow and power of resistance to stress. Hence, the particles cannot flow uniformly and uninterruptedly, even if they were not hindered in doing so by laminations, and, since rupture takes place at the weakest point, so likewise is contraction determined by local conditions principally and not by the condition of the whole mass of metal except there be ideal uniformity.

Moreover, unlike stretch, which becomes a measurable quantity at an early stage of the testing, contraction takes place chiefly between the period when the ultimate strength is reached to the point of fracture. It is, therefore, the last gasp, as it were, in the life of the metal tested, and a careful engineer does not expect his structure to break down. The difficulty of measuring the per cent. of contraction with anything approaching accuracy also tends to make this method of testing an unsatisfactory and unreliable one from a practical standpoint.

The fact that contraction is not uniformly proportional to strength, but shows an irregular, varying percentage, while elongation is more or less proportional to strength, also shows that reduction of area is an exponent of local rather than general conditions.

With special high-grade steel, like gun forgings and short

test pieces, it may be that reduction of area has some practical value, but such exception cannot be applied to the enormous masses of structural material of all kinds produced and used under the stress of everyday competition and manifold applications.

While elongation is the resultant of the stretch of every cross section of the area stretched, hence gives an average of the total variations of the whole section, reduction of area gives only the ability to contract at that portion of the section where the test piece breaks, which point includes only a few of the many cross sections into which the section may be divided.

Therefore, the larger the test section, other things being equal, the less representative a quality-measure reduction of area is, leaving out now all other considerations. These few test pieces explain this very well.

The practical value of the drop test as a quality measure is more and more appreciated by the engineer.

Iron and steel, when repeatedly subjected to dynamic stresses, shocks, blows or vibrations, is affected differently than when only static stresses are active to destroy a structure or part of a structure.

During a tensile test there is ample time for the quick-flowing molecules of structural iron and steel to adjust themselves to new conditions, induced by the stress operating to destroy the metal. Under the sudden shock of a drop test every individual particle is put on its own merits.

If the cohesion with which the particles are held together is inferior, there will be separation under but a few blows. If there is irregularity of structure, microscopic nests or veins of impurities or flaws, then such defects will act like wedges driven between the structure, and fracture will be from inward out.

To resist sudden shock successfully, the metal must be able to transmit the vibrations caused by the blow on the particles directly struck from particle to particle in the shortest possible time. If the tremor caused at the point of impact is not conveyed or conducted away quickly and distributed uniformly throughout the mass of metal, if the tremor is arrested by flaws,

laminations, segregations, irregularity of structure, etc., or if the metal is too brittle, does not cushion enough, as it were, then the metal will soon separate along the cleavage lines of the crystals and break under a few blows.

Hence the drop test as a measure of shock-resisting power is a very practical method of testing, provided the blows are heavy enough. If they are not heavy enough to bring out the possible defects at the first two or three blows, every succeeding blow heats the metal, causing a change of structure, thus minimizing certain defects that may exist in the metal. The function then of the drop or impact test of any kind is, first, to determine the presence of such defects which mechanically separate the particles of the metal, or, in other words, impair their intimate contact and adhesion, and, second, to determine the ability of the metal, other things being equal, to absorb, as it were, to convey and distribute over every—even the smallest—cross section of the metal the vibrations produced on its surface by shocks, in order to prevent the overstraining, and hence fatiguing, of any cross section of the metal at the expense of its neighbors, thus producing early fracture.

The nicking and bending tests are extremely valuable, either for themselves or as auxiliaries to the tensile test.

Nicking a piece of steel or iron on one side and breaking it quickly will show several things. If iron, a nicking test will show whether it is clean or dirty, short fibered or long fibered, dry or juicy, coarse crystalline, due to cold shortness, or that fine, mushy, silvery granulation so characteristic of burnt iron. In steel the nicking will show laminations, shortness and, to a certain extent, want of uniformity of heating of the material in the mill, if there are many pieces of the same kind of metal to be tested..

The bending test is quite a reliable measure of ductility, more so for middling hard grades of steel, from boiler grade up, than for the softer kinds. Steel flows so easily under even moderate pressures that a dead-soft piece of steel must be very bad indeed if it will not stand bending double without signs of distress. What makes the bending test valuable with middling hard steel is the severe strain the bending imposes on the

cohesive power which holds the particles of the steel together.

Generally speaking, steel consists of two distinct bodies, a harder body, forming the crystalline portion, imbedded in a softer mass. We have reason to believe that the hard body predominates in the harder grades of steel, while it forms but a small percentage of the total mass in the soft grades. It is the soft body chiefly which imparts ductility to steel.

Now it is clear that, in order to produce maximum resistance to rupture, the union between these two bodies must be at its best in order to resist the severe strain on the convex surface of a bent piece of steel.

For this reason, if the convex surface has a velvety appearance without exhibiting the least skin cracks even, we have a right to conclude that a piece of steel thus tested is of very good quality, always provided that the bend is sufficiently large to strain the metal to its utmost. For these reasons also bending tests on square or cornered bars are more severe than on round ones. The above points are also applicable to iron with certain modifications.

Under certain conditions the nicking and bending test may become much more valuable and reliable as a quality measure than the tensile test.

The elongation, measured around the convex surface of a bent piece of steel, is often found to be equal, or a little more, to the elongation in a 2-inch section of a tensile test.

The nick-bending test is still more effective than the nicking test alone or the bending test alone. A piece of structural iron or steel must be very good indeed to suffer bending upon itself after having been nicked, which is meant by a nick-bending test.

Especially on steel is this a very severe test, because, if the crystals of steel are once separated anywhere in the mass, this separation is readily continued along the cleavage faces where the crystals adhere to each other by their sides. To be able, therefore, to bend a nicked piece of steel upon itself means superior cohesion of the particles, which, if the strength is sufficient, means an excellent material for constructive purposes.

The quenching test as a measure of quality and practical

utility may be considered of doubtful value. So many variables enter into the successful performance of this test that it is very easy to produce such conditions as will nullify the object we intend to accomplish.

A successful quenching test requires the uniformly carrying out of the details to be observed more accurately than any other test, because the heat employed will produce different effects from those we expect to get if that degree of heat is not in conformity with the point at which the chemical elements change in the steel.

The investigations of Osmond, Brinnel, Charpy, Arnold, Hadfield, Saveur, Howe and others point to the conclusion that the changes in properties in steel due to heat treatment take final and definite shape within well-defined and somewhat-narrow limits. Below these limits complete change of elements does not take place.

In ordinary annealing, experienced judgment is a sufficiently close guide to produce the effects we desire. In the process of tempering tools we are guided by the variously-colored films of oxide forming on the steel.

In the specifications for quenching tests we usually find the empirical statement of "cherry heat," or the still-less intelligent expression "blood heat."

These terms are applied to all grades of structural steel, notwithstanding the fact that the effects we intend to produce by these degrees of heat are not alike on all grades of steel. In other words, since variation in the percentage of chemical elements in steel require varying degrees of heat to produce a desired change, the now uniformly applied so-called "cherry" or "blood heat" will produce varying effects on the piece quenched without our knowing what these effects really are.

Thus the operation of quenching as usually performed is a crude guesswork, a hit or miss performance, unjust to the manufacturer and misleading to the engineer.

To do justice with a quenching test to ourselves and others we ought to specify the chemical composition the material to be quenched ought to have, the degree of temperature at which that particular change of chemical elements takes place which

is to produce the effect we expect and desire, and the degree of temperature of the quenching fluid at which the change of elements in the steel becomes fixed.

Brief and incomplete as the foregoing explanation is, it will probably indicate that the performing of a proper and reliable quenching test requires knowledge of the carbon contents of the steel to begin with and the measuring, by means of a pyrometer, the degree of heat of the steel just as much as we measure the temperature of the quenching fluid. Only with the co-operation of these three factors can we claim practical usfulness for the quenching test.

Routine transverse tests are principally made on cast iron and other hard material.

On account of the absence of the restraining influence of grips or holders, every particle of the metal in a transverse test piece is free to act, and, therefore, such a test is a reliable measure of ductility and homogeneity.

Especially for cast iron this test is preferable to a tensile test of that metal. The ductility of cast iron is very small, and what little viscosity there is is overbalanced by the rigidity of the metal to such an extent that there is no measurable flow, and, therefore, fracture takes place with the beginning of flow, and no measurable elongation is obtained in a tensile test of cast iron. What little ductility there is is hindered from becoming manifest by the restraining influence of grips and the eccentricity of the pull of the testing machine.

Whatever eccentricity there is in a testing machine, however small, in the test of a cast-iron test piece it is sufficient to snap off the piece sideways before the small amount of ductility there is has time to assert itself. This is probably the reason that, while we get no elongation in a tensile test of cast iron, the same iron tested transversely will give from $\frac{8}{100}$ to $\frac{1}{10}$ of an inch deflection, showing that, while our method is in conformity with the nature of the metal under test, the other method is not.

Only when there is a long-continued series of cast-iron tensile tests made under the same conditions with the same mixture is a tensile test of cast iron of approximate value, because

then the error of eccentricity practically becomes inoperative as to result.

In the foregoing the author has not taken into consideration the possible influences of internal strains in cast iron, and of which Mr. A. E. Outerbridge has made so successful a study.

Crushing, shearing, punching and torsion tests are special tests, not used frequently as commercial tests, and, therefore, are not discussed at present.

Hammer tests are seldom made, although they are very valuable.

Drifting tests are used in bridge material, and are very effective tests for ascertaining ductility and homogeneity.

Fatigue tests will not come into general use as commercial tests because of the length of time necessary to make such tests.

At present we find specifications for fatigue test of stay-bolt iron in satisfactory operation. The underlying idea of this method of testing is to imitate the effects of the movements of a locomotive boiler, or rather its fire-box, caused by contraction and expansion on the stay-bolts of a boiler. While such imitation of natural causes can only be approximate, there is reason, nevertheless, to believe that such commercial-fatigue tests will prove of considerable practical value.

While the microscopic examination of iron and steel has not yet attained to the dignity of a commercial method of testing, yet the growing use of the microscope in mills and testing rooms gives promise that ere long this valuable auxiliary to the physical test and chemical analysis will be accorded its proper place as a standard method of testing, and thus justify the expectations of the pioneers of this valuable work, Sorby, in England; Martens, in Germany, and F. L. Garrison and C. Roepper, in this country.

The study of the microstructure of steel has not yet evolved fixed laws by which the practical value of a given structure of steel may be called standard.

But that much we know, that the microscope is to lead to a solution of some metallurgical problems, especially the effect of heat treatment, with all its apparent changes of structure and physical behavior.

From what little work the author has seen done with the microscope by others and has done himself, he cannot share the enthusiasm of those who claim that the microscope will supersede the chemical laboratory in its usefulness.

Summarizing our very brief inquiry into the practical aspect of present commercial methods of testing iron and steel, we find that in some of these methods we are following the laws of nature, while in others we are trying to squeeze the properties of these valuable metals into the straight jacket of conventional rules and methods with consequent unreliability of results.

Much as we know about the properties and qualities of iron and steel, there is still more to be learned.

However, there is a growing sentiment and desire in many quarters for information and thorough investigation, and the author sincerely hopes for the hearty co-operation of the Franklin Institute and the International Association for the Unification of Methods of Testing Materials of Construction, as well as the manufacturers and engineers of the country, to bring about that understanding of the properties and qualities of iron and steel and uniformity of methods of testing these metals for the mutual benefit of our commerce and our industries and the welfare and prosperity of our country and all countries, for science has no nationality.

DISCUSSION.

THE PRESIDENT OF THE SECTION:—I am sure that I express the unanimous sentiment of the members of the Mining and Metallurgical Section of the Franklin Institute when I say that we are much indebted to Mr. Kreuzpointner for his instructive and interesting contribution to our rapidly-growing literature upon the important subject of testing iron and steel.

The able addresses on this and cognate topics, which have followed each other month by month since the formation of this section a little more than a year ago, have proved that its creation was timely, and I am convinced that its future is bright with promise of still further expansion and usefulness.

Mr. Kreuzpointner has skilfully avoided falling into an error common to experts in discussing their specialties, of contracting their vision within the range of a very limited horizon; he has taken a broad view, and his introductory words recall to my mind some remarks of a French engineer, who visited this country about a year ago, and whose shrewd observations on the economics of American industries were extensively quoted in technical periodicals at home and abroad; he attributed the phenomenal advancement of this country in all mechanical industries mainly to the close attention given to technical details.

Mr. Kreuzpointner has unflinchingly pointed out facts in his discussion of the present methods of testing iron and steel, which may, perhaps, appear discouraging but knowledge of our shortcomings is really the first step towards advancement, and I think you will agree that there are a number of so-called "mysteries" waiting to be cleared up in connection with this subject. Sir Benjamin Baker marshalled before the engineering world many unexplained phenomena of metals in his presidential address at the "Institution of Civil Engineers," in 1895. If I correctly remember the substance of his remarks, he said something like this: "Who can tell what mysterious changes are occurring day by day, week by week, year by year, in metals, such, for instance, as hardened steel projectiles, leading sometimes to their violent disruption; who can explain that great mystery of the bridge links from the old Hammersmith Bridge made of the toughest iron, which, after successfully withstanding sixty years of hard usage, snapped in two by the score while being shipped to Edinburgh, although, when the halves of the broken links were subsequently thrown down from the top of the Forth Bridge on to the rocks 300 feet below, they bent like cockscrews, without fracture?"

Many years ago, Sir William Thomson (Lord Kelvin) showed that iron rods or wires, which were kept in torsional oscillation during the week, behaved very differently after a rest over Sunday, and these observations have been confirmed and elaborated by others. Sir Benjamin Baker stated that it has been recently shown that owing to the molecular settlement which occurs during rest in an overstrained bar,

the modulus of elasticity will rise 10 per cent. after three weeks' holiday.

The present methods of testing cast iron, and of determining therefrom the strength of castings made of this metal, are ludicrously or rather lamentably faulty, and they will, no doubt, so continue to be until engineers learn to appreciate more clearly the enormous influence that the rate of cooling exerts upon its physical properties. In this respect cast iron differs radically from cast steel or from other metals. The strength of cast iron test bars is not a safe guide upon which to predicate the strength of iron castings unless all of the relative conditions are known and taken into consideration. For instance, if you will cast from one ladle of iron two test bars, preferably in the same mold, one let us say, of 4 inch, the other of 1 inch section, turn them to the same dimensions and pull them upon a testing machine, you will probably find—I may say I am sure of it—that one of the test pieces will be *at least 50 per cent. stronger than the other!* I know that such a startling statement may seem incredible to any one not familiar with the facts, but I speak thus definitely and positively from experience.

The subject of Mr. Kreuzpointner's paper is open for discussion, and I am glad to recognize in the audience several gentlemen who are themselves experts in such work. I hope that they will express their views, and I will call upon Mr. Backstrom who, I know, has had years of experience in testing iron and steel, using the well-known "Emery" testing machine for that purpose, to say a few words upon the subject.

MR. G. L. BACKSTROM:—I do not agree with the author and his statement that cast iron has not perceptible elongation.

In numerous tests I have had occasion to make myself I have found elongations, ranging from ·15 to ·45 of 1 per cent., in cupola iron, and while specimen was under strain, and I think that the elongation of a cast-iron specimen will enable one to form a pretty good idea of the quality of the material being tested.

As to the difficulty of making reliable tests on cast iron, I lay that wholly to defective apparatus and carelessness of

operator. Proper preparation of specimen and a machine in perfect alignment will overcome these difficulties.

MR. JAMES S. WHITNEY:—Referring to tests of cast iron, I have in mind the "thermal test" now enforced by the Pennsylvania Railroad to try the quality of chilled iron car wheels. It may be remembered that this test consists in subjecting the cast wheel, when cold after annealing, to the sudden heat of a ring of molten metal poured around the chilled rim or "tread." This is done to roughly simulate the action of brakes, which on long down-grades is frequently sufficient to crack the gray iron plate of the wheel partially away from the tread by the expansion of the latter due to the heat generated.

The metal may be such as to stand the "drop test" and yet fail in the "thermal test." In view of the considerable differences in both the temperature and rate of cooling of molten cast iron of different chemical proportions, it would appear reasonable that some limits should be imposed as to the kind of molten iron to be used for this ring, and the pouring temperature. A close-grained metal used for brake shoes not only may come from cupola much hotter than wheel iron, but also loses its heat more rapidly at first, as our tests with an optical pyrometer have shown.

MR. KREUZPOINTNER made answer that the thermal test being a foundry test for wheels was not in his department, but that he believed it to be a good practical test, and that the requirement that the wheel should not break into two or more pieces within two minutes after pouring the ring, assured to the Pennsylvania Railroad a safer quality in the cast of wheels represented by the test wheel than if the drop test alone was relied upon.

At the wheel foundry of the Pennsylvania Railroad at Altoona molten wheel iron from the regular run for wheels is used for this test, and the moulders are quite expert in judging the temperature of the iron before pouring the wheels, being docked for loss of wheels poured too hot or too cold. Hence there is every probability that the iron used for making the thermal test is neither too hot nor too cold.

As to Mr. Backstrom's remark about there being some stretch in a tensile test of cast iron, I beg to say that I am

well aware of this fact. However, all my remarks made here to-night apply only to commercial methods of testing, and in the everyday practice of commercial testing it is simply out of question to use continually sufficient time and such scientific methods and elaborate instruments as are necessary to determine the elongation of a tensile test-piece of cast iron. Since the easily-measured deflection of a transverse test-piece of cast iron answers all the purposes of commercial testing, the latter method of testing cast iron appears to be more reliable, and therefore preferable whenever more or less rapid work becomes a necessity.

MR. ASA W. WHITNEY:—In the case of the drop test there appears to be a relation between the quality of resilience, as shown by the slow deflection of a transverse test bar, and the quality of metal which longest endures the shock of the drop test on a casting in form of a chilled wheel. Of course, this relation is complicated by the capacity of the metal for chill. But for same depth and quality of chill as shown in the wheel or chill test, the resilience $\left(=\frac{\text{stress} \times \text{deflection}}{2 \times \text{weight of bar}}\right)$ of 4″ area hexagon bar indicates quite fairly the quality or relative number of blows under the drop test when in form of a chilled wheel. Only by very close regulation of cupola charges for many years on a strictly chemical basis has it been possible to observe the relations of this kind in the narrow ranges of figures indicating practically equivalent chemical compositions. Further study may indicate a similar physical relation to the thermal test besides limiting chemical composition in certain directions, though thorough annealing is a very important point.

THE RIGHT TO PROPERTY IN AN IDEA.*

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DEFINITIONS.

Webster defines the term "property" in part as follows:

"*Property.*—(3) The exclusive right of possessing, enjoying, and disposing of a thing; ownership; title. (4) That to which a person has a legal title, whether in his possession or not; thing owned; an estate, whether in lands, goods, or money.

"*Literary Property.*—Property which consists in written or printed compositions. The exclusive right of publication as recognized and limited by law."

INTRODUCTORY.

The avowed object of all honest anarchists, socialists, reformers of every class of opinion and degree of intelligence; the dreams of all philosophers, poets, and prophets; the teachings of every professor of ethics, morals and economics; the mission of all governments and of all religion is to cause men everywhere to understand the principles of justice, to incarnate them in their lives as a controlling motive power and force, inspiring and guiding their thoughts and actions. All efforts of the past; all agitations of to-day, all hopes for the future having as an objective point the betterment of the whole of humanity, morally, socially, and economically, may be rightly interpreted as a demand for justice. Every cause for discontent; every political issue will be permanently and satisfactorily removed or settled when all men recognize that so far as human agencies in the affairs of men are operative, justice is done. A review of the past, a careful summary of the present aspect of all public questions teaches and emphasizes one fact: *The people want justice, but they do not know how to obtain it.*

* A lecture delivered before the Franklin Institute, November 26, 1897.

Justice is born of honesty and intelligence. *Honesty* is the image of God in the hearts of men. *Intelligence* is a condition of mind. Granting the presence of honesty in the hearts of the people, their lack of knowledge as to how to obtain justice and their failure to secure justice must be ascribed to defective intelligence. Honesty will cause all men to wish to do justice, but the degree of justice which they do will be measured by their own standard, by their conception or understanding of the principles of justice. If the action of any man is unjust, the cause of the injustice must issue either from a deficiency in honesty or a defective intelligence. As all whose opinions are worthy of consideration claim a full measure of honesty, attention need be directed only to their mental development.

Close observation will disclose the fact that in their attempts to obtain justice those who have directed the thought and energies of the people have centered attention upon efforts to formulate and enforce demands for justice, rather than upon efforts to so educate men as to cause each one to do justice, under any and all conditions, whether his action is directed towards a fellow-man, a family, a municipality, State or nation, or the universal society of humanity. The universal demand for justice can be satisfied by each man doing justice, and in no other way. The problem of how to obtain justice for all men, individually and collectively, will be completely and correctly solved by causing the actions of all men, individually and collectively, to be just. When individual action is just, collective action will be just also. Just collective action is impossible so long as collective society, large or small, is composed of men whose conception of the principles of justice is defective. It is the duty of all who study the welfare of humanity from the view point of the rights and duties of the individual or from the rights and duties of collective society, any grouping of individuals, large or small, to give the problem of how to cause every individual action to be just their most serious attention. This question once solved, all other problems for the moral and economic betterment of the people will become simple and easy of solution or cease to exist.

THE RIGHT TO PROPERTY IN AN IDEA.

The best test for the correctness of a person's conception of the principles of justice, or of his honesty, is his willingness to recognize, and, recognizing, to give compensation for the right to property in an idea. This is true, because ideas, being the most intangible of all products of labor, are the most difficult to protect by the requirements and punishments possible to enacted law. Many persons whose moral sense of right and wrong is sufficiently clear to protect them from any desire to steal anything protected by enacted law feel no restraining influence from their conscience to retard them from taking anything not so protected and appropriating it to their own benefit without tendering compensation to its author, even when they know the author, and know he has need of a just compensation for his labor. The necessity for plainly-stated enacted laws, defining what may and what may not be freely taken for the exclusive use or enjoyment of individuals, singly or collectively, is created by the inability of many persons clearly to perceive the principles of justice, to understand their requirements, and to govern their actions in accordance therewith. Compensation is due from each individual for every intellectual benefit received, to some person or group of persons working collectively for educational, charitable, religious, or industrial economic purposes; or for the proper government of a municipality, State, or nation, or for all of humanity.

Defective moral vision causes those who are benefited by society and government to feel no rebuke of conscience when they neglect their civic duties. The most important function of society or government is the protection of individuals in their just right to life and property. The necessity for such protection is the basis of the right of governments to exact the payment of taxes for their support. This necessity, and the taxation caused by it, will become less and less arduous as enacted laws become more just and are honestly and intelligently obeyed or executed.

An idea unexpressed is in the undisputed possession of him who conceives it, but it has no tangible existence. It cannot be communicated to others without being given a form, more

or less tangible, in words or signs voiced or written. When given a tangible existence, by what rule of justice can it become, without compensation, the property of another not its author. In so far as society fails to give to an author the protection necessary to enable him to enforce his right to property in his own ideas, society permits every one to take and use them freely, without rendering compensation for them. It permits those who will to be legally unjust. In this way the interests of authors are sacrificed for the common good. A law clearly securing to every author the right to property in his ideas will not prevent any author from becoming a public benefactor. He can voluntarily relinquish his right, by deed to the government, and thus enrich all to whom his ideas are of value, and by the same act prevent others from claiming a property right in them.

THE RIGHT TO PROPERTY IN DISCOVERIES AND INVENTIONS.

The right to property justly adheres to the acquisitions of close observations resulting in the discovery of gems, precious metals, useful natural materials and mechanical principles; and in the invention of devices for controlling and utilizing the resources and forces of nature. In every department of thought a mind may project itself beyond the boundary of the discovered and broaden the sphere of knowledge by making clear that which had not previously been understood, or bringing to view the hitherto unknown. The right to property in ideas that lead to such results, and to the results obtained by them, is as just as the right to property in the things produced by manual labor employed to mould the idea into a concrete form that can be offered for sale as a new creation. It is the duty of society to do justice by protecting every author, discoverer, and inventor in his right to property in his ideas as well as in the products of his physical labor.

AUTHORS MUST PAY THEIR DEBTS.

While every person should be protected in the ownership of all that is justly his own, no person should be protected in the ownership of more than his own. Every useful idea, dis-

covery or invention is based upon the work of those who lived before. Every person who now makes a tool or writes a philosophical statement is assisted by the work of those who have passed to a sphere where rights to property are unknown, and also by the labor of his contemporaries. By that order of nature which sets a limit to the life of the body, the results of the work done by those who once lived, and which they once rightfully owned as their property, become the common heritage of all the living. The dead cannot own property.

Improvements, additional adaptations, new ideas and inventions, are suggested to the minds of careful observers. In this manner are induced all improvements in industry; facilities of every kind; comforts of every description; entertainments of every class, and the power more perfectly to utilize the resources and forces of nature. Out of the stock of common knowledge ideas spring. The known suggests that which may be known.

If ideas, discoveries and inventions are suggested by observation of what others have done, what is due to society from authors, discoverers, inventors, in fact, from all owners of property? If society had failed to protect the laborer in his right to own the results of his labor; if the author, discoverer or inventor had been denied an opportunity to observe existing things, to draw upon the resources and forces of nature which are the property of no one, but are a part of the common inheritance; or, if they had been debarred from all access to the stock of common knowledge, is it conceivable that the product of labor would have been saved, or that the idea, discovery, or invention would have been his?

The principles of justice operate with impartial force upon the conduct of individuals towards society, as upon the conduct of society toward individuals. The requirements of justice which confirm to each person all that is rightfully his own, require that he shall have no more than his own. More than is rightfully his own no one can have without doing an injustice to another. To do justice every person must give to society full compensation for the benefits he receives from society, not only for its protection of his right to property, but

for the assistance he obtains from existing things, from natural resources and forces, and from the stock of common knowledge. The man who causes two blades of grass to grow where but one grew before, and keeps both blades for himself, together with all knowledge of how he accomplished such a result, is not a benefactor of his race. His benefaction, if any, is in proportion to the division he makes with others of his extraordinary increase, and the extent to which he permits his valuable knowledge to be diffused, without compensation, through the stock of common knowledge, thus making it a free heritage of all.

The reimbursement to society, voluntarily or exacted, for benefits received, intangible or tangible, is a requirement that cannot be determined with exact justice. The human mind is not yet sufficiently endowed with the power of intelligent judgment and honest action to enable it to do complete justice under all conditions. It must be content with doing substantial justice, being guided thereto by the demands of equity.

COPYRIGHT AND PATENT LAWS.

Copyright and patent laws are framed on the principles of equity. They should give equal recognition to the rights of individuals and of society. They should divide an accruing benefit for a brief period between an author and society, and beyond that transfer the entire increment of information to the stock of common knowledge from which all may take freely. The life of an individual is brief. The life of society is continuous. It is good policy to offer a proper inducement for the desired achievement. The highest good of society, of any collective group, as of individuals, requires that it shall develop itself to the best of which it is capable. This is its right and its duty. If, by securing to an author, discoverer, or inventor of a useful idea or thing an opportunity to realize for his own a profit, during a part of his life, no matter how large, profit cannot be out of proportion to usefulness, society can stimulate all minds to do their best, it will not only enrich itself by the activity of the living, it will inherit rich endowments from those who pass beyond the jurisdiction of its enactments.

If there were, however, never a question as to the right to property in an idea, discovery or invention, there would be a necessity for copyright and patent laws, and for the system of administration founded upon them. On account of the fact that all ideas, discoveries and inventions are outgrowths of suggestions from the known, it is a common occurrence to have several persons, almost simultaneously, honestly claim to be the original and only pioneer to lead and advance in literature, science, art or industry. To make and keep correct records whereby conflicting claims so arising may be justly settled, is as important, and, if the judgment of all men were perfect, would be the only function of government in such cases. Founded and administered to do justice, society can better afford to broaden than to restrict the application and scope of its copyright and patent laws.

WHAT IS PROPERTY?

The inquiry may now be made in its broadest sense, what is property?

Property consists of all things of value which may be owned by the consent of society, given in recognition of its conception of the principles of justice, by an individual, or by any collective group. The *property quality* of things of value is created by the consent of society practically expressed through the means it employs to protect owners in their right to possess, enjoy, and dispose of that which they may legally own. I say *consent of society*, because there can be no property where there is no social consent or contract to protect anyone's right to possession.

If no one recognizes a thing as having value, no one wants to own it, therefore, no protection is required to make possession of it sure. It is not property. A thing recognized as having value, ownership of which is not confirmed by the consent of society, cannot be exchanged for other things having value, because all are permitted freely to take it, therefore no protection is granted to make possession of it sure. It is not property. Things of value, the ownership of which is not confirmed by the consent of society, are those things upon which

no labor has beeen expended. Justice requires that every laborer shall be unmolested in the possession and enjoyment of the products of his toil. In recognition of this demand, society grants protection for the right to own all things created by labor. This protection constitutes such things property.

THE BASIS OF THE RIGHT TO OWN PROPERTY.

It is now necessary to examine the basis upon which the right to own property rests.

The consent of society to the ownership of things of value is based upon its conception of the principles of justice. This conception of justice is expressed by enacted law. The divine law is the moral and the enacted law is the legal basis to all right to own property. This right is founded on the natural right of a creator to possess the products of his creation, his labor. This is the demand of justice. This right is conceded by all who honestly and intelligently demand or seek to do justice. This is the basis of the title to all property whether owned individually or collectively by two or more persons for their private use and benefit, or by associations, municipalities, States, or nations for the common use and benefit of all members, citizens or subjects.

Protection is assured by the operation of moral and physical forces. The most effective protection is given by a correct understanding of, and a desire to obey moral law. Moral law teaches honesty as a principle. Economic law enforces honesty as a practice. Man must understand and willingly obey the principles of moral law before he can understand and correctly apply the principles of economic law. When no person will permit himself to be unjust there will be no injustice. Barring the factor of knowledge, the absence of which may render one unable to determine to whom a thing of value rightly belongs, the right to property will be completely protected without the presence or the use of enacted law, or of its representative physical forces, when the moral law is correctly understood and universally obeyed.

Once, when walking in Central Park, New York, I chanced to hear a few words exchanged between two young girls who were walking near me:

"Let's pick some flowers," said one.

"Oh! I daren't," answered the other.

"Come on, the policeman won't catch us, he is around the turn in the walk behind the bushes," persisted the first.

"I daren't catch myself stealing," replied the second, as she passed on, admiring but not touching the flowers.

If the high sense of honor, the clear-sighted self-respect of that little girl controlled the actions of every person, stealing would be an unknown vice, the protection of property by physical force would be an unknown burden upon the industrious.

In proportion as self-respect is strong or weak, asserting and maintaining a high standard of honor in individuals and in society, is the right to property respected or disregarded. Regard of the right to property determines the position of an individual in the scale of moral development, from vicious brute to conscientious man. In proportion as regard of the right to property is strong or weak in individuals and in society are men civilized or brutal, and in proportion as men are civilized or brutal, do they recognize and respect the sacredness of life and property.

A clear recognition of the right to property is necessary to the protection of life. This is illustrated daily by the acts of men engaged in robbery or the wanton destruction of property. When so engaged they do not hesitate to take life to save themselves from capture. It is conceded that the right to life is valued above all other rights. It is clear that protection of the right to life and property is based on justice, and is made most effectual by a correct understanding of and disposition to apply the principles of justice. The intelligence to recognize these principles, the power to incarnate them and to make them a governing force guiding his every action, raises man above the brute and constitutes him another and a higher order of being. There can be no moral or economic government among brutes.

Whenever a change occurs in the popular conception of the principles of justice, either through a clearer understanding or a misinterpretation of moral law, and by reason of such change society withdraws its consent to the ownership of any

class of property, all things so affected cease to be property. Against the destruction of property by such a cause property owners have no defense. When a popular verdict has once declared that the right to own a certain thing or class of things shall cease, owners of such property are powerless to maintain the right to ownership even though they defend it with their lives. This fact has an epoch-making illustration in the destruction of property in slaves caused by the withdrawal of the consent of society to such ownership, voiced by the emancipation proclamation issued by Abraham Lincoln, President of the United States.

LIMITATIONS ON THE RIGHT TO OWN AND USE PROPERTY.

The natural right of every person to own and use as he pleases the products of his labor, his ideas, discoveries and inventions can be fully exercised only when he is isolated. In a state of isolation there is no property. As soon as a man associates with another his natural right to do as he pleases with his own is modified by a due regard for the similar rights of others. By association society is formed. The welfare of society requires that protection to the right to property it grants for individual good shall not be used to the injury of anyone, or of society. Should it be, it is the duty of society, in defense of its welfare, to withdraw consent and thus destroy the property. The fundamental principles of justice require that all property shall be owned and used with a due regard for the similar rights of others. Rights to the ownership and use of property are not vested rights. They are not absolute. They are qualified by the principles and conditions that give them existence.

The expenses of government incurred in behalf of the protection it affords to the ownership of property must be collected from the property it protects. Government frequently exercises its sovereign power and dispossesses the owner of property, by public sale, to satisfy its claims for taxes, giving title to the buyer. Rights to property that can be thus annulled are not vested rights. They are not absolute. They are created, and may be destroyed by the consent of society.

In a final analysis it is clear that the ownership of all property is protected, not by constitutions, enacted laws or decisions of courts, but by the consent of society based on its conception of the principles of justice. Changes in the popular conception of these principles or of their proper application may cause existing constitutions, enacted laws and court decisions to be out of harmony with the popular belief as to what is just and right. Such a change will cause existing conditions to appear unjust. A people stung to the quick by a sense of injustice, believing themselves to be the victims of unjust laws, an unjust administration of laws, or of an unjust industrial, commercial or financial system, will not cease to agitate, nor ought they to cease to agitate, until every change is made that is necessary to bring the constitutions and enacted laws upon which court decisions are based into strict accord with their conceptions of the principles of justice.

Such changes are steps of progress in civilization when in the right direction. They are steps of retrogression when in the wrong direction. When they come by the peaceful processes of evolution, the new absorbs and utilizes all of good that can be found in the old with injury to none. When they come by the destructive processes of revolution the suspicions, prejudices and discontent of the people, having brewed an anger that cannot be controlled, it bursts forth in a wild fury and destroys the old in order to secure an opportunity to create a new government or an industrial system that will accord with their conceptions of justice. It is not in the power of any man or class of men permanently to prevent the oncoming of these changes. Delayed they may be. Directed they can be. No power can stop them absolutely. The life of nature finds expression in change. When changes cease, humanity and all nature will be dead. It is idle to resist a tendency to change. It is the highest wisdom to guide it in a right direction.

These truths should cause everyone to realize that all rights to property, of whatever kind, depend upon the correct moral and economic education of the people. Every property owner should realize that the protection of his right to ownership depends primarily upon a correct conception of the principles of justice by the people, not upon the use of force. When

an appeal to force is made sufficiently drastic to arouse all of the people, it will be found that millions who toil wield the balance of power, and that they cannot wield it justly when they are not guided by a correct conception of the principles of justice. A state of inaction cannot be maintained. History is repeating itself. Conditions are rapidly developing, such as lead to revolution. Men can remain free only by recognizing the correct principles of justice and properly applying them in every detail of their affairs. Happiness cannot exist without freedom. Freedom cannot live when justice is not done. The time has come when the American people must make progress by means of correct moral and economic education or by revolution.

THE ECONOMIC LAW OF LABOR AND PROPERTY.

The natural law of labor and property is founded on the principles of moral and economic law. Being a natural law it is universal in its application and binding upon all men. In discussing this subject elsewhere I have said:

"In isolation a man has undisputed possession of the surplus products of his labor. * * * The natural right of the isolated to the undisputed possession of the product of his labor and to be unrestricted in the use or disposition he may make of it cannot be enjoyed by associated men except as it is qualified by a due regard for the similar right of others. This is the foundation of the natural law of labor and property.

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"If, prompted by an ignorant self-interest, one man decides to take more than his just share of the joint product of himself and others, because he is stronger and has the brute power to do so, such a violation of natural moral law removes the transaction from the domain of economic science and carries it back to the domain of moral science. The brute must be taught the moral law, and have intelligence enough to understand it and honor enough to obey it before he can be dealt with as an economic factor."*

* "The Law of Incorporated Companies, Operating Under Municipal Franchises." See chapter under the title of "The Economic Law of Labor and Property." Robert Clark Company, Cincinnati, O.

The laborer and the capitalist must yield obedience to the requirements of justice if justice is to be established. Neither can secure a permanent gain by violating the economic law and taking an unjust share of their joint products. Justice cannot permit any person to be a permanent gainer by his own acts of injustice.

THE NATURAL LAW OF JUSTICE.

The natural law of justice is superior to all constitutions, all enacted laws, all court decisions. It is uninfluenced by the opinions or actions of men. It is the only correct ideal. It is the only changeless standard. Rightly understood and obeyed it will enable all men to realize the highest attainable good. Disregarded, whether through ignorance or through vicious selfishness, it punishes with imperious and merciless exactness every step of divergence from a true course. In no age have the ablest men comprehended all there is of wisdom. In every age the toiling masses have failed to understand and to utilize all the wisdom formulated for their guidance and the betterment of their condition. Slowly and painfully they have been working their way towards the realization of higher and still higher ideals, sometimes helped and many times hindered by their trusted leaders. The entire experience of mankind confirms the correctness of the theory that man is ennobled or degraded by the truth or error contained in his beliefs. Whenever a clearer understanding of the natural law detects an error in a conception of the principles of justice, and the affairs of men are re-aligned in accordance with the requirements of the new light, civilization and human happiness make a distinct gain. Whenever a conception of the principles of justice is clouded by suspicion, prejudice or vicious selfishness, and the affairs of men are blindly aligned by false standards, civilization receives a disastrous blow. Happiness is stabbed in its heart.

In this aspect of the subject it is a solemn duty to direct attention to the fact that thousands of advocates are ceaselessly working to miseducate the people. They are poisoning the minds of the people with sinister suggestions and prejudices founded on falsehoods, to which they give currency in the

guise of facts. They are creating a sense of injustice by magnifying imaginary wrongs. They are preparing the way for a widespread destruction of property through the dissemination of false conceptions of the principles of justice. If their work is not promptly and thoroughly counteracted by correct moral and economic education, a disaster, such as the cause of civilization has not suffered since the dark ages, will come. Political development has reached a point at which choice must be made between doing the work of correctly educating the people or suffering the disaster of a revolution.

This is neither the time nor place to amplify this note of warning. But I beg to assure everyone to whom these words may come that they are written with a full knowledge of their serious import based on facts that admit of no doubting. These facts have been made possible by the activity of the dishonest and of the misinformed; and also by the apathy of those who rely upon enacted law and the use of force to protect them in the possession of that which they call their property. Unless property owners perform their civic duties far more perfectly than they have done in the past, the day will come when this reliance will fail them. Millions of workmen are being taught that the property of the wealthy has been acquired by robbery, and that, "*When a man is robbed, the way for him to get money is not to work for it but to fight for it.*" When that idea has taken possession of a sufficient number, the power of existing enacted laws to protect the right to such property will fail. The destruction of one class of property to satisfy demands not correctly based on the natural law of justice will not satisfy, it will only stimulate the anger of the misguided. A well-defined movement in a wrong direction cannot be stopped until it has gone far beyond the limits originally assigned for it by those through whose ill-judged work its inception and momentum are due. On the day when those having false conceptions of the principles of justice gain control of the government, municipal, State or national, calamity will come. The falsity or correctness of any person's conceptions may be shown by his ability or disposition to recognize the right to property in an idea. This is the kind of property most difficult to protect by law,

therefore it is the most easily stolen. A man who will steal because he safely can is honest or just only when he must be. A man who is honest or just only by compulsion has not the spirit of honesty or justice in him.

AN ECONOMIC DELUSION.

All men are endowed with equal natural rights but not with equal natural conditions or capabilities. The teaching that "All men who do their best do the same"* is an economic delusion. No one more readily recognizes differences in capabilities than honest-hearted, clear-headed men who work under the direction of others.

Whatever a person may justly claim is his by right, not by favor. Less than this no man should be permitted to demand or receive. What one cannot give in justice to himself another cannot justly take from him. Justice to self is a true measure of justice to others. The Divine command is, "*Do unto others as you would have others do unto you.*" This command requires every man to be sure that his own acts are just, rather than to be the judge of the actions of others by demanding justice for himself. No man can comply with this command without doing justice. No man can obey this command who fails to recognize the differences in natural or acquired capabilities existing between himself and others.

The history of mankind presents a panorama of the rise and fall of civilizations. Men have ever been reaching after but have never fully grasped and comprehended the great truth which teaches the two-fold character of the products of life—character and property. The greater always includes the lesser interest, yet men for ages have blindly sacrificed character for the sake of property. Every feature of the economic law of labor and property must be correctly understood and rightly obeyed before a person can develop the best possible character. Moral law is the foundation of economic law. Economic law completes moral law. One cannot be rightly observed while the other is being violated.

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* "Equality." Edward Bellamy.

THE TREASURES OF WISDOM.

All that has been said pertains to ideas that may be made tangible, imprisoned in concrete forms and offered for sale in the market place. They are of the earth. Beyond them, enveloping them, as the earth is enveloped by its atmosphere, is the realm of thought. There the society of mind exists; a society in which property is unknown. There the wise of all ages hold communion. There consent is given not to own but to freely take all that any one is capable of receiving. None can hear the conversation of the wise who cannot understand them. In that society the property values for which men so earnestly contend have no meaning. The treasures of wisdom need no guarding. They elude destruction. They increase by being shared. In the realm of the society of mind it is clearly understood that the things of greatest value are priceless. There no one will sacrifice character for property. There one would be known as a loser who should give his character, his soul, in exchange for the whole world. What infinite folly is it then for practical business men to risk an impairment of character to gain even the largest wealth anyone has ever been able to grasp. No man can be unjust to a fellow-man and wrong him out of the enjoyment of anything that is justly his without blindly sacrificing the greater for the lesser good. All so inclined should know that it is impossible for the justice of God, which overrules the affairs of men, to permit anyone to be a permanent gainer by acts of his own injustice. In the name of all who labor, justice is demanded by all who wisely, or unwisely, work for social reforms. For the welfare of all who toil with hands or brain let everyone be taught to be just. When all are just, the right to property in ideas, or in any other form, will need no guarding, no affirmation.

THE FRANKLIN INSTITUTE.

Stated Meeting, Wednesday, April 20, 1898.

RECENT IMPROVEMENT IN X-RAY TUBES.

By H. Lyman Sayen.

The most important considerations in the manufacture of Roentgen-ray apparatus are those influenced by the value of the apparatus to physicians and hospitals. Now that the scientific world has recovered from the suddenness of this discovery of æther-energy, which is so closely allied with light and electricity and yet without experimental proof of the nature of its energy, investigation goes on with surer and even more-rapid strides than it did immediately after Professor Roentgen's announcement.

Investigators, both physical and medical, have become specific in their lines of research, and the large demand for apparatus has caused such competition among manufacturers that many useful improvements are the result. The manufacturers themselves, perhaps, do as much practical work in this direction as any one else. They know the faults of their own apparatus, and these deficiencies are ever before them in complaints from operators, so that it is quite a problem to furnish a good outfit capable of being easily managed by a physician or layman with satisfactory results for any length of time.

An induction coil or static machine will, with any reasonable care, last indefinitely. The manipulation of the dry plate is the same as in ordinary photography, requiring only a knowledge of developing, fixing, etc. The difficulties are chiefly met with, however, in the operation of the high-vacuum tube, in which so many factors are to be considered in achieving satisfactory work. Up to the present time I do not believe that there has been discovered a more-efficient generator of X-rays than a piece of platinum bombarded by so-called "radiant matter."

Here it may perhaps be interesting to indulge in a little speculation on "radiant matter." Faraday, who first used the

expression, defines it thus, "If we can conceive a change as far beyond vaporization as that is above fluidity, and then take into account also the proportional increased extent of alteration as the changes rise, we shall, perhaps, if we can form any conception at all, not fall far short of 'radiant matter,' and as in the last conversion many qualities were lost, so here many more would disappear." Dr. William Crookes, in 1876, made public his highly-interesting experiments with tubes carried to such a degree of exhaustion that the gases therein were in the so-called "radiant" state. In his papers he calls attention to the fact that gases are composed of an almost infinite number of small particles or molecules, which are constantly moving in every direction with velocities of all conceivable magnitudes. Owing to the great number of these molecules it is impossible for them to move an appreciable distance before they collide with one of their fellows. If the pressure of the gas be diminished, the distance which the molecule can move is proportionately increased. This average distance he calls the mean free path of the molecule. If the pressure be so decreased that the mean free path is comparable with the dimensions of the containing vessel, the matter is then in the so-called "radiant state," and the molecules are free to bound forwards and backwards across the tube. These molecules radiate from a negatively-excited pole with enormous velocity, producing many phenomena wherever they strike. Crookes constructed a number of very ingenious tubes to show the novel and characteristic properties of radiant matter, and he assigned the following properties to it: Radiant matter exerts a powerful phosporogenic action where it strikes. It proceeds in straight lines. When intercepted by solid mater it casts a shadow. It exerts strong mechanical action where it strikes. Radiant matter produces heat when its motion is arrested.

To show this last property, he made a small tube containing a thin platinum plate placed in the focus of a converging stream of radiant matter. A weak current from the secondary of an induction coil is sufficient to heat the platinum red hot. Had Crookes gone a little further in his experiment he would have found that not only heat and phosphorescence manifest them-

selves, but also that these molecular collisions give rise to an æther disturbance of such a character as to excite phosphorescence not only inside the tube but also outside of it. It would also have been demonstrated that this disturbance radiates in straight lines, suffering no refraction, reflection, or any other of the phenomena incident to ordinary light, and that all substances are more or less transparent to it. In this way he would have antedated Professor Roentgen by more than thirty years.

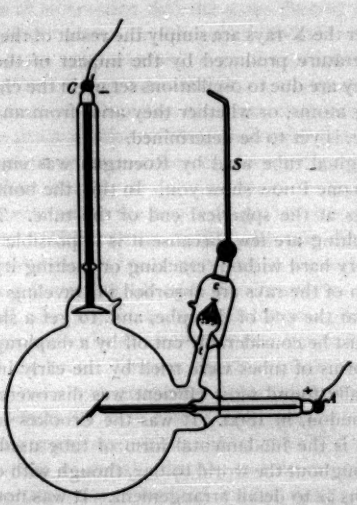
Whether the X-rays are simply the result of the enormously high temperature produced by the impact of the molecules, whether they are due to oscillations set up in the charges on the discharging atoms, or whether they arise from an entirely different cause, is yet to be determined.

The original tube used by Roentgen was similar in construction to one I now show you. In this, the bombardment is on the glass at the spherical end of the tube. The efficient X-rays resulting are few, because it is impossible to bombard the glass very hard without cracking or melting it; a considerable portion of the rays are absorbed in traveling through the thick glass at the end of the tube, and, to get a sharp picture, the light must be considerably cut off by a diaphraghm. Practically all forms of tubes were tried by the early investigators, the one finally found most efficient was discovered at King's College, London, in 1892. It was the Crookes hot-platinum tube. This is the fundamental form of tube used by various makers throughout the world to-day, though with considerable modifications as to detail arrangement. It was not long, however, before a great difficulty manifested itself in the use of high-vacuum tubes for X-ray work, and that was the rise in vacuum subsequent to their constant use. Many attempts were made to remedy this defect, but they all lacked success from the very fact that the vacuum was in too a fickle a state for the human hand to manage. The vacuum in a Roentgen-ray tube can vary only over very small limits, and, being also dependent on the temperature of the tube, it is in a very unstable position. Thus, if a tube starts to heat when running, the vacuum lowers and the tube takes more current, due to the

increased conductivity of the gas therein, lowering the vacuum still more; a reversed condition of affairs takes place if the tube starts to cool. It will, therefore, be seen that it is very difficult and often impossible to keep the temperature of a tube constant, and to manage a non-automatic regulating device. The ideal regulating device should possess the following qualities:

(1) It should act immediately.

(2) It should be independent of the temperature of the tube.



C, cathode terminal; *A*, anode terminal; *S*, adjustable spark point; *c*, cathode auxiliary tube; *t*, communicating tube; *B*, potash bulb.

(3) It should maintain the desired vacuum unvaryingly.

Having these difficulties in mind and the qualities desired, I designed for Queen & Co. a tube, which I fully described before the Electrical Section of the Institute about a year ago. It is unecessary in this connection to do more than refer to the principles involved in its construction. Its operation depends upon two phenomena, viz., the variation of the electrical re-

sistance of the gas in the tube due to different degrees of vacuum, and to the fact that certain salts will give off vapor on being warmed, re-absorbing it on cooling.

A reference to the figure will make the operation of the tube clear. A small bulb containing a substance which gives off vapor on being heated and re-absorbs it as it cools is directly connected to the main tube and surrounded by an auxiliary tube, which is exhausted to a low Crookes vacuum. In the auxiliary tube the cathode is opposite the above-mentioned bulb, so that any discharge through it will heat this bulb. This cathode is connected in an adjustable spark point, which can be set at any desired distance from the cathode terminal of the main tube. In operation, the induction coil is connected as usual to the main bulb. On starting the coil, the vacuum of the main tube being high, its resistance is also high, and the current takes the path of least resistance through the auxiliary tube, thereby heating the substance in the small bulb. This will continue for a few seconds, until a sufficient amount of gas has been evolved to bring down the resistance of the main tube. After this only an occasional spark will jump across the gap sufficient to maintain the tube at the same vacuum. As the spark point is adjustable, the vacuum may be set high or low by varying the distances between it and the main tube.

Practical work has demonstrated that a tube must possess the following characteristics in order to secure efficient results:

(1) The vacuum should be adjustable to permit the ready employment of the tube in various kinds of work.

In a radiograph of the hand, it is desirable to use a low vacuum in order to secure good contrast between the bones and the flesh, while a high vacuum is necessary to locate foreign metallic bodies in the denser muscular or bony tissues.

(2) It should require a minimum amount of attention from the operator during the operation.

(3) It must be able to hold its vacuum continuously for an indefinite period.

(4) It must be able to carry a large current in order to generate powerful X-rays, thereby consuming as little time as possible in making the exposure.

(5) It should have sharp definition, *i. e.*, the source of X-rays should be as small as possible without interfering with the efficiency of the tube.

In designing the tube shown in the figure, and which I shall now put in operation, all the foregoing points received careful consideration. The principle of self-regulation is identical with that first employed in the original design. This tube is made in two sizes, one with a larger bulb and heavier platinum suitable for powerful currents. In the larger tube the platinum is reinforced by welding an extra thickness underneath, the platinum being very thick immediately under the focal point of the cathode stream. The cathode is made of aluminum, hand-hammered to prevent rapid deterioration. It is ground and polished to a curve of a radius of one inch. It may seem curious, but it is a fact, that the rays focus at a point, the distance of which from the cathode is dependent on the height of vacuum. After once having come to a focus, they seem to continue in the form of a pencil until they strike the platinum. The cathode rays do not cross each other at all. This is not true, however, for very low vacua in which they do cross.

The small bulb containing the gas-producing substance is made with a conical side towards the bombarding cathode, in order that the heat shall be well and evenly distributed over its surface. This allows the substance to get the full benefit of the heat generated without the liability of the bulb cracking, due to an excessive current. The conical point of the bulb is protected by sealing in it a little piece of platinum wire welded to a piece of foil of the same material.

THE ZEUNER DIAGRAM.

By William Fox,
Assistant Professor of Applied Mathematics.

(*Concluded from vol. cxlv, p. 393.*)

Problem 10.—Given (*Fig. 1*) points C, P, A, and L. A line through L perpendicular to $A\ L$ will cut the line $C\ P$ (produced) in point E.

Problem 11.—Similar to Problem 9. Given points L and D. The perpendiculars drawn to $L\ C$ and $D\ C$, through the points L and D respectively, will intersect at the point E.

Problem 12.—The lines through $E\ B$ and $E\ D$ are respectively perpendicular to the lines $C\ B$ and $C\ D$.

Problem 13.—(*Fig. 2*) $S\ T$ is perpendicular $C\ N$ at C. Any two of the indefinite lines $C\ M$, $C\ E$ and $C\ K$ (*Fig. 1*) being given, the third one is found by making the angles $M\ C\ E$ and $E\ C\ K$ equal. Lay off distance $C\ I = i$ on $C\ T$. Through point I draw a line parallel to the line $C\ R$ bisecting the angle $\alpha = K\ C\ N$. This line intersects $C\ E$ in point F. Make $C\ O = C\ F$ and draw $O\ K$ perpendicular to $O\ C$ and cutting $C\ K$ in point K. Then will $C\ K = r$.

For $$\frac{i}{C\ O} = \frac{\sin.\ \frac{\gamma}{2}}{\cos.\ \frac{\alpha}{2}}$$ (as in Probl. 6.)

Hence $$C\ O = r\ \sin.\ \alpha = C\ K\ \sin.\ \alpha$$

Another solution may be obtained by assuming any value for r say r_1.

Then $$r_1\ (\cos.\ \beta - \cos.\ \overline{\alpha - \beta}) = i_1$$

and $$r\ (\cos.\ \beta - \cos.\ \overline{\alpha - \beta}) = i$$ (Eq. 5.)

Hence $$\frac{r}{r_1} = \frac{i}{i_1}$$

where r_1 i_1 and i are known, and which can be solved graphically in the usual way.

Problem 14.—From equations (1) and (2) we get

$$p = r - r\ cos.\ \beta + i$$

$$(p - i) = r\ (1 - cos.\ \beta) = 2\ r\ sin^2.\ \frac{\beta}{2}$$

$$\frac{(p - i)\ cos.\ \frac{\beta}{2}}{sin.\ \frac{\beta}{2}} = 2\ r\ sin.\ \frac{\beta}{2}\ cos.\ \frac{\beta}{2} = r\ sin.\ \beta$$

or

$$(p - i)\ tan.\ \left(90° - \frac{\beta}{2}\right) = r\ sin.\ \beta \qquad (8)$$

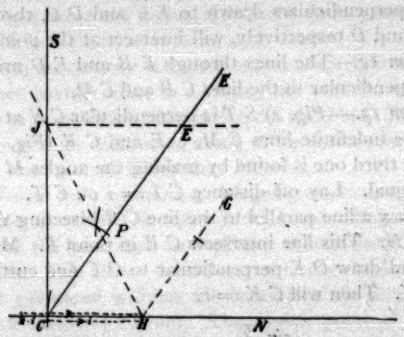


FIG. 4.

Given the point C and the perpendiculars $C\ S$ and $C\ N$ (*Fig. 4*). On $C\ N$ lay off $C\ H = p - i$, and draw through H a line $H\ G$ parallel to the β line $C\ E'$; bisect the angle $G\ H\ C$ by the line $H\ J$, cutting $C\ S$ in point J. The line $J\ E$ drawn perpendicular to $C\ S$ will cut the β line in point E, giving $C\ E = r$. The lap is found by laying off the distance $E\ P = p$ on $C\ E$.

From the figure we see

$$J\ C = H\ C\ tan.\ J\ H\ C = C\ E\ cos.\ E\ C\ J$$

or

$$(p - i)\ tan.\ \frac{180° - \beta}{2} = C\ E\ sin.\ \beta$$

Comparing this with equation (8) above, it is evident that $C\,E = r$.

Problem 15.—This is the *bête noir* corresponding to Spangler's Problem IV.

I suggest the following solution as being somewhat simpler than Professor Spangler's:

Draw the lines $C\,N$ and $S\,T$ (*Fig. 5*) as before.

On $S\,T$ lay off $C\,I = i$ and $I\,Y = p$, then $Y\,C = p - i$.

Draw the line $C\,K$ making the angle $K\,C\,N = \alpha$, and on $C\,K$ lay off $C\,Y' = C\,Y$. Project the point Y' on $S\,C$ to point Q and draw the arc, laying off C Q' on $C\,N$ equal to $C\,Q$. At

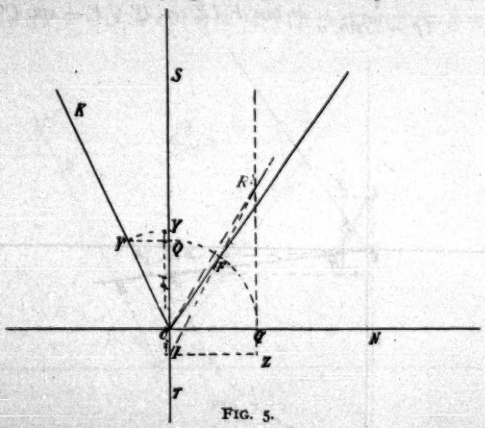


FIG. 5.

Q' erect a perpendicular and find the point R where a line bisecting the angle α intersects the perpendicular.

Join R and I by a line, cutting the circle $Q\,Q'$ at the point F. Then will the line $F\,C$ make the angle β with $C\,N$.

Proof: Prolong the line $R\,Q'$ to the point Z making $Q'\,Z = i$.

$$R\,Q' = Q'\,C\,tan.\,R\,C\,Q'$$

$$= Y'\,C\,sin.\,\alpha\,tan.\,\frac{\alpha}{2}$$

$$= Y'\,C\,.\,2\,sin.^2\,\frac{\alpha}{2}$$

Hence, $R\,Q' = Y'\,C\,(1 - cos.\,a) = (p - i)\,(1 - cos\,a.)$

and $R\,Z = (p - i)\,(1 - cos.\,a) + i$

and $$\frac{R\,Z}{C\,Q'} = tan.\,R\,I\,Z = \frac{(p - i)\,(1 - cos.\,a) + i}{(p - i)\,sin.\,a} \qquad (A)$$

In the triangle $C\,F\,I$

$$\frac{C\,I}{C\,F} = \frac{sin.\,C\,F\,I}{sin.\,(90° - F\,I\,Z)} = \frac{sin.\,(Q\,C\,F - C\,I\,F)}{cos.\,F\,I\,Z} =$$

$$\frac{sin.\,(Q\,C\,F - 90° + F\,I\,Z)}{cos.\,F\,I\,Z} = \frac{sin.\,(F\,I\,Z - Q'\,C\,F)}{cos.\,F\,I\,Z}$$

or $$\frac{i}{(p - i)\,sin.\,a} = tan.\,F\,I\,Z\,cos.\,Q'\,C\,F - sin.\,Q'\,C\,F.$$

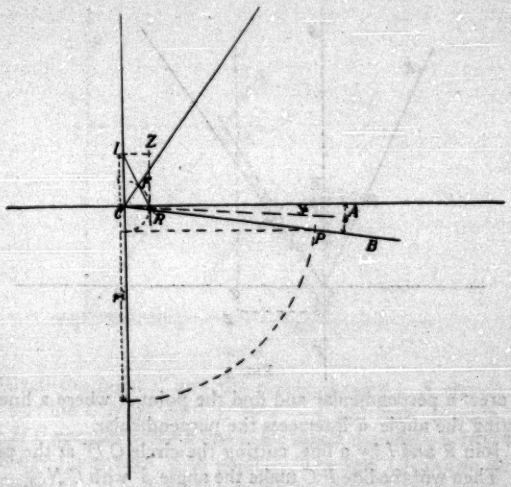


FIG. 6.

From previous equation (A), since $F\,I\,Z = R\,I\,Z$

$$\frac{i}{(p - i)\,sin.\,a} = \frac{(p - i)\,(1 - cos.\,a) + i}{(p - i)\,sin.\,a}\,cos.\,Q'\,C\,F - sin.\,Q'\,C\,F \qquad (B)$$

Now equation (5) is

$$r\,cos.\,\beta - r\,cos.\,(a - \beta) = i$$

and on combining (1) and (3) we have

$$r = \frac{p}{1 - \cos.(\alpha - \beta)} \tag{9}$$

whence with (5) above

$$p \cos.\beta - p \cos.(\alpha - \beta) = i - i \cos.(\alpha - \beta)$$

$$p \cos.\beta - (p - i) \cos.(\alpha - \beta) = i$$

$$(p - i) \cos.\beta - (p - i) \cos.(\alpha - \beta) = i - i \cos.\beta$$

$$(p - i) \cos.\beta - (p - i) \cos.\alpha \cos.\beta - (p - i) \sin.\alpha \sin.\beta + i \cos.\beta = i$$

$$\cos.\beta\,[(p - i)(1 - \cos.\alpha) + i] - (p - i) \sin.\alpha \sin.\beta = i$$

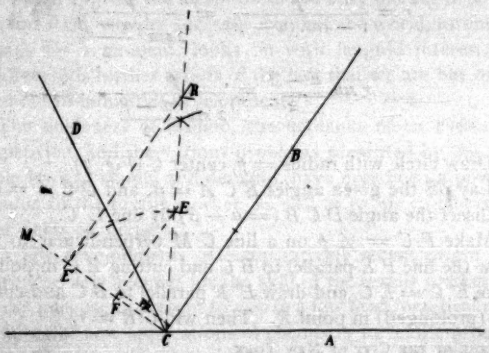


FIG. 7.

Dividing both members by $(p - i) \sin.\alpha$

$$\frac{i}{(p - i) \sin.\alpha} = \frac{(p - i)(1 - \cos.\alpha) + i}{(p - i) \sin.\alpha} \cos.\beta - \sin.\beta \tag{10}$$

This is identical with Equation (B), and hence $< Q'\ C\ F = \beta$.

The other quantities can be found by Problem 14.

Problem 16.—We can readily derive similar to Equation (10):

$$\frac{i}{(p - i) \sin.\eta} = \frac{(p - i)(1 - \cos.\eta) + i}{(p - i) \sin.\eta} \cos.\beta + \sin.\beta \tag{11}$$

Fig. 6, similar to *Fig. 5*, shows the work, the scale being twice the scale of *Fig. 1*.

It is evident that $< C F I = < F C A + < Z I F$

Hence $$\frac{i}{(p - i)\ sin.\ \eta} = \frac{sin.\ (F C A + Z I F)}{sin.\ (90° - Z I F)} =$$

$$tan.\ Z I F\ cos.\ F C A + sin.\ F C A$$

where $tan.\ Z I F = \frac{(p - i)(1 - cos.\ \eta) + i}{(p - i)\ sin.\ \eta}$ like eq. (A)

Comparing this with Equation (11), we find $< F C A = \beta$

Problem 17.—Equation (9) gives

$$r = \frac{p}{1 - cos.\ (\alpha - \beta)} = \frac{p}{2\ sin.^2 \frac{\alpha - \beta}{2}}$$

or $$r\ sin.\ \frac{\alpha - \beta}{2} = \frac{p}{2\ sin.\ \frac{\alpha - \beta}{2}}$$

Draw circle with radius $= p$, center C (*Fig. 7*).

Lay off the given angles $B C A = \beta$, and $D C A = \alpha$.

Bisect the angle $D C B$ $(= \alpha - \beta)$ by line $E C$.

Make $F C = \frac{1}{2} p$ on a line $C M$ perpendicular to $B C$. Draw the line $F E$ parallel to $B C$ and cutting $E C$ in point E. Make $E' C = E C$, and draw $E' R$ parallel to $B C$ and cutting $E C$ (prolonged) in point R. Then will $C R = r$.

College of the City of New York,
New York, March, 1896.

CHEMICAL SECTION.

Stated Meeting, Tuesday, March 15, 1898.

SOME RECENT DEVELOPMENTS IN TEXTILE PROCESSES.

By Aron Hamburger.

The cry of the civilized world is, and has always been, for novelty. In the multitude of mechanical and industrial pursuits which engross the attention of the busy worker in laboratory and shop, wonder succeeds wonder; the world, astonished perhaps for a moment, looks on with languid interest, and then demands further proofs of the fact that we are but on the threshold of industrial development.

The fickleness of fashion, the demands of an ever-active competition, and the various problems presented by the inexorable laws of supply and demand, have ever been a powerful stimulus to the textile worker, as well as to his co-laborers in other fields of industry.

A few developments of comparatively recent origin seem to promise new avenues for the skill of the textile worker, and it is my purpose to present to you in a few brief, practical notes, a number of new applications of chemistry to textile processes which are engrossing the attention of American and European mills and dyehouses.

On account of its high luster, great strength and elasticity, and its affinity for nearly all artificial and natural coloring matters, the fiber excreted by the many species of silk worm has always held the highest place in the estimation of textile-manufacturing nations.

The great demand for silk for ornamental and useful purposes, and its high intrinsic value, have been the incentives for many efforts towards its artificial production.

While nothing has yet been brought forward which has been capable of displacing silk in the textile industry, interest-

ing progress has been made in the art of imparting a silk luster and appearance to other and cheaper fibers.

As early as 1844 John Mercer, a cotton printer, of Lancashire, England, discovered that, when subjected to a strong solution of caustic soda or caustic potash, cotton fibers became greatly contracted in length, as well as more dense, and to a high degree capable of being directly dyed with basis dyestuffs.

He made this discovery the basis of broad patents, which were issued to him in England and in continental countries in 1850, and, to quote the original patent application, his claims were as follows:

"The invention consists in subjecting vegetable fabrics and fibrous materials, cotton, flax, etc., either in the raw or manufactured state, to the action of caustic soda or caustic potash, dilute sulphuric acid, or chloride of zinc, of a strength and temperature sufficient to produce the new effects, and to give the new properties to them which I have hereafter described.

MERCER'S INVENTION DESCRIBED.

"The mode I adopt of carrying into operation my invention to cloth, made wholly or partially from any vegetable fibers, bleached, is as follows: I pass the cloth through a padding machine charged with caustic soda, or caustic potash, at 60° or 70° Twaddell's hydrometer, at the common temperature, at say 60° F. or under, and, without drying the cloth, wash it in water, then pass through dilute sulphuric acid and wash again, or I run the cloth over and under a series of rollers in a cistern with caustic soda or caustic potash at from 40° to 50° of Twaddell's hydrometer, at the common temperature of the atmosphere, the last two rollers being set so as to squeeze the excess of potash back into the cistern; the cloth then passes over and under rollers, placed in a series of cisterns charged at the commencement of the operation with water only, so that, at the last cistern, the alkali has been nearly all washed out of the cloth; when the cloth has either gone through the padding machine or through the cisterns above described, I wash the cloth in water, pass it through dilute sulphuric acid, and wash it again in water.

"When I adapt the invention to gray or unbleached cloth, made from the fibrous material before mentioned, I first boil or steep the cloth in water, so as to have it thoroughly wet, and remove most of the water by the squeezers or hydro-extractor, and then pass the cloth through the soda or potash solution, etc., and proceed as before described.

MERCER'S INVENTION APPLIED TO WARPS.

"I apply my invention in the same way to warps, either bleached or unbleached. By this process I produce on cotton and other vegetable fabrics and fibers effects somewhat analogous to that which is produced on woolen by the process of fulling or milling. It will have acquired greater strength and firmness, each fiber requiring greater force to break it. It will also have become heavier than it was before it was acted on by the alkali, if in both cases it be weighed at the temperature of 60° F. or under. It will have acquired greatly augmented and improved powers of receiving colors in printing and dyeing.

EFFECTS OF THE APPLICATION.

"The effects of the application of my invention to the vegetable fiber in any of its various stages before it is manufactured into cloth will be readily understood by reference to its effects upon cloth composed of such fibers.

"Secondly, I employ sulphuric acid diluted to 105° Twaddell's hydrometer, and at 60° F. or under. I use this acid mixture instead of caustic potash or soda, and operate in all respects the same as when I use soda or potash, except the last souring, which is here unnecessary.

"Thirdly, when I employ solution of chloride of zinc, instead of soda or potash, I use the solution at 145° F., and operate in all respects the same as when I use soda or potash.

"When I operate on mixed fabrics, partly of vegetable and partly of silk, woolen, or other animal fibers, such as delaines or leans, etc., I prefer the strength of the alkali not to be above 40° Twaddell's hydrometer and the heat not above 50° F., lest the animal fibers should be injured.

CONCLUDING REMARKS.

"I may, in conclusion, remark that the description of the apparatus or machinery and the strength and temperature of the soda or potash, sulphuric acid or chloride of zinc solution, may be varied to a considerable extent, and will produce proportionate effects without at all deviating from my invention. For instance, caustic potash or soda may be used even as low as 20° Twaddell's hydrometer, and still give improved properties to cotton, etc., in receiving colors in printing and dyeing, particularly if the heat be low, for the lower the temperature the more effectively the soda or potash acts on the fibrous material above described. I, therefore, do not confine myself to any particular strength or temperature of the substances I employ, but the particular strength, heat, and processes here described are what I have found the best, and what I prefer.

"And I claim as of my invention the subjection of cotton, linen and other vegetable fibrous material, either in the fiber or any stage of its manufacture, either alone or mixed with silk, woolen or other animal fibrous material to the action of caustic soda or caustic potash, dilute sulphuric acid, or solution of chloride of zinc of a temperature and strength sufficient to produce the new effects, and to give to them the new properties above described, either by padding, printing or steeping, immersion or any other mode of handling."

Notwithstanding the great expectations aroused among cotton manufacturers by Mercer's patents, so-called mercerized cotton has, until recently, assumed little importance because the contraction of the fiber in all directions made cotton cloth so treated much more expensive, and the advantage gained never appealed to the handler as being sufficiently strong to compensate for the increased cost of production.

Within the last two years, however, an accidental discovery in connection with mercerizing cotton has opened a new field of usefulness for this process, and the silk-lustering of cotton yarns or cloth by means of solutions of caustic alkalies or similar reagents, presents many possibilities.

A textile chemist in Germany, whose name at this writing escapes my memory, was experimenting with a fabric com-

posed of equal parts of silk and cotton with a veiw to the acquisition of some means by which piece goods of this description might be colored evenly in one bath.

In one experiment he treated his cotton yarns with a strong solution of caustic soda while holding same in a stretched condition, and, to his great surprise and delight, noted the fact that the cotton fiber had assumed a silky luster and appearance, and could be dyed in very fast and bright shades without losing its fine silk-like appearance.

As a result of this happy accident, manufacturers in all parts of the world have been experimenting on similar lines, and, through the courtesy of the J. R. Montgomery Company, of Windsor Locks, Conn., which is very successfully manufacturing these silk-lustered cotton yarns on a large scale, I am enabled to present for your examination some very handsome samples of this yarn, which is easily dyed and may readily be woven into durable and handsome fabrics.

To obtain this silk luster and finish, the best method to be pursued is as follows: Yarns, warps or piece goods in a stretched condition are immersed in a solution of sodium hydrate (caustic soda) for about fifteen minutes, strength of bath to be about 52° Twaddell.

The cotton goods thus treated are then passed through squeeze rolls, or are hydro-extracted, to remove excess of alkali, and are then thoroughly rinsed with clear water.

A second bath of dilute sulphuric acid suffices to neutralize all remaining alkali, when a thorough final rinsing leaves the yarn in condition for either dyeing or bleaching.

The character of yarns employed for this purpose has a marked influence on the luster and finish obtained, as soft-twisted and double yarns made from long staple Egyptian or Sea Island cotton give decidedly the best results. Hard-twisted yarns and single yarns of ordinary cotton acquire luster and a greater affinity for dyestuffs, but they are inferior in appearance to those made of soft-twisted double yarns from Egyptian or Sea Island cotton.

As a result of the uniform contraction of the fiber, due to this process, these yarns have a tensile strength of from 25 to

40 per cent. greater than before treatment, and this property adds greatly to the advantage to be derived from the use of such material in the manufacture of articles for ordinary wear.

The silk touch and feel or "scroop," as it is called, may be obtained on mercerized yarns by treating them after dyeing or bleaching with alternate baths of olive-oil soap and calcium chloride, as follows:

The dyed or bleached yarns (or cloth) are first passed through a bath made up of one pound neutral olive-oil soap dissolved in twenty-five gallons of water. The yarns are then hydro-extracted and passed through a 1 per-cent. solution of calcium chloride, and afterwards washed and steamed lightly.

This precipitation of a lime soap (principally calcium oleate) on the fiber imparts the peculiar silky feeling so much desired in the manufacture of dress goods, hosiery, underwear, etc.

Where this scroop is not of particular benefit, it is always well to soap the dyed or bleached yarns or goods with a good neutral olive-oil soap, which adds softness and improves the luster.

To insure even lustering I have always found that it is better to use a weaker solution of alkali and longer immersion therein, rather than a stronger caustic bath and a shorter treatment.

A 52° Twaddell solution of caustic soda is as strong as necessary, and the average time of immersion should not be over fifteen minutes.

Stretching and twisting on suitable machines after the mercerizing, also tend to heighten luster, and are recommended to all handlers of this material.

Since the first notes on this method of silk-lustering appeared, many other reagents have been recommended in the place of the caustic alkalies, but few if any of them appear to present any practical advantage.

One method, patented in Germany, calls for the use of a mercerizing bath made up of 30 per cent. of sodium or potassium sulphide, to which is added 10 per cent. of any of the following fat solvents (which float on top of the alkaline sulphide solution, so that the yarns or cloth pass first through the sol-

vent and then through the sulphide), methyl or ethyl alcohol, benzol, aniline oil, paraffine oil, petroleum or turpentine.

As the yarns or goods treated with caustic soda or potash are, as a rule, boiled out and freed from impurity before entering the bath, this method, which I have carefully tried, costs more than the other, and does not seem to give any better results.

Another application of this mercerizing process to textile fabrics is mentioned in a late number of the *Textile Manufacturer*, of Manchester, England, from which I quote:

GLOSS ON COTTON AND LINEN GOODS.

"Among the very recent processes for obtaining a silk-like gloss effect on fibers and fabrics is one devised by the Farbwerke, of Hoechst-am-Main, and described in the *Textile Manufacturer*, of Manchester, England.

"The object of this is to produce durable effects on both cotton and linen stuffs. To do this they employ the modified mercerizing system of Thomas & Prevost, by applying appropriate resisting styles capable of neutralizing the mercerizing effects of soda lye upon the fabric in the state of tension. By these means they claim to obtain a new, valuable and technical effect. It is known that it has been impossible hitherto to produce damask-like gloss effects of perfect durability by means of the dyeing or printing processes. The methods employed until now were, as a rule, limited to printing with oxide of zinc, barium sulphate, etc., combined with a fixing agent (albumen, caseine, etc.), on tissues of sateen-like weaving and gloss dressing in order to thus neutralize the sateen gloss, and of the tissue by means of this locally-fixed white color. While the gloss produced by this sateen weaving cannot be compared with real silk gloss and with that obtained on cotton by Thomas & Prevost's system, and must be regarded merely as an effect of weaving and a particular method of dressing, it is to be observed that the silk gloss of mercerized cotton in a state of tension is obtained by a chemical and physical change of the cotton fiber.

"It is a fact that the mercerizing of the cotton in a state of

tension causes the lumen of the fiber to shrink, to become transparent, and to undergo great changes on its surface which produce this lasting silk-like gloss. Also, from a chemical point of view, the fiber undergoes an advantageous change, and it is generally known that, since Mercer's experiments, the affinity of cotton fiber towards mordants and dyestuffs is considerably increased by the influence of strong soda lyes and agents acting in a similar manner (concentrated sulphuric acid, solution of chloride of zinc). It is, therefore, possible to produce this mercerizing effect on fabrics locally, under conditions as specified by Thomas & Prevost (tension), either by means of printing with concentrated soda lye or by protection of the fiber against the mercerizing effect of the soda lye, a durable and damask-like effect being thus obtained. The substances suitable for the resisting style are easily coagulable organic bodies, such as albumen, caseine, etc., as well as salts, acids or oxides, which partly have a neutralizing effect, or provide the fiber with a protecting film of an oxide.

"The resisting action of these bodies against soda lye is not new. With the help of these bodies the most varied white and colored gimping effects were obtained, while the object of the present process is to avoid the shrinking of the tissue and the silk gloss thus caused.

"In the description of a German patent particular stress is laid upon the circumstance that the printed resisting style—albumen, caseine, etc., or mixtures of gum with acetates of aluminium or chromium—becomes insoluble by previously steaming, and thus forms an inseparable compound with the fiber. In order to obtain the intended effect, the applied resisting styles need not be steamed, and the possibility thus created of effecting a subsequent removal of the albumen, or the encrusting protecting substances, is in many cases a great advantage. As the silk-like gloss produced on the tissues in form of patterns, according to this method, is very durable, such cloths may be afterwards dyed, printed, steamed and washed without danger to the gloss. It is likewise possible to produce the most varied printing effects with durable silk gloss by the addition of mordants or dyestuffs to the resisting styles or to the mer-

cerizing soda lye. The printing of the resisting styles and the mercerizing may be done separately or in succession on the printing machine; in the latter case the printed cloth, on leaving the roller, is stretched by means of an appropriate stretching apparatus. The washing in a stretched condition is continued until the tension of the inner fiber has ceased.

"The following is an example of an appropriate printing color:

"Mercerizing color for direct printing, 70 grams British gum and 930 grams soda lye (40° B.), or 100 grams wheat starch, 200 grams water, and 2,000 grams soda lye (40° B.).

"*Resisting Color.*—Albumen solution, 10°, 700 grams, and dilute solution of gum tragacanth 300 grams.

"We might add further that the microscopical appearance of cotton mercerized by the process of Thomas & Prevost differs from that of ordinary cotton in a striking and typical manner. The mercerized fibers mounted in water generally appear stretched and smooth, only showing the twisted appearance in places, or not at all. Those fibers which possess the well-known twisted appearance have a large lumen and are little changed. The fibers from the outside portion of the yarn show, in consequence of the greater tension, longitudinal folds, while those from the inside frequently show transverse crushed folds.

"The surface of the fibers often shows an intermittent double stripe. The cuticular layer is generally completely demolished. The lumen of the fibers in places is greatly enlarged; in others it appears as a dark line, while in others it has entirely vanished. The enlarged portions of the lumen are frequently filled with a granular mass. In polarized light the fibers behave just like ordinary cotton."

The extensive use of mohair and lustrous wools in the manufacture of braid yarns and dress goods, etc., has led to many experiments with ordinary wools to secure silky appearance and luster, and while a perfectly satisfactory process has not yet been obtained, some very interesting results of a more or less practical value have been arrived at through the use of various oxidizing agents, most prominent of which are chlorine and bromine in dilute solutions.

The combination of fatty-acid precipitation with energetic oxidation by means of sodium or calcium hypochlorite is the basis of the following formulæ, which have given me good silky luster, but which have a more or less tendering action on the fiber.

For light shades on 20 pounds of knitting yarn, take the soluble part of 3 pounds of calcium hypochlorite (bleaching powder) dissolved in 150 gallons of water, with from 3 to 4 pounds of HCl. Work for from 30 to 45 minutes at 140° to 158° Fahr.

For dark shades use, for same quantity of yarn and same amount of water, 6 pounds hypochlorite of calcium and 3 pounds HCl, working for 45 minutes at 122° Fahr.

For use on either dark or light shades take 100 gallons sodium hypochlorite liquor, testing ½° B., with 6 pounds HCl, and treat for 30 minutes at 122° Fahr.

Another method, perhaps better on account of lessened tendency to yellow the fiber, is to treat for 30 minutes at 86° to 95° F. with a bromine solution of from 5 to 8 per cent. strength; but, while this method has a better effect on the strength of the fiber than chlorine, the luster is less brilliant.

In all cases much care is necessary that the operation be not prolonged beyond the specified time, that the temperature be not permitted to rise too high, and that the yarns be turned constantly so as to insure uniform oxidation.

As wool fiber is always more or less discolored by this treatment, it is necessary to bleach before dyeing, aqueous sulphurous acid being best adapted for this purpose. Silk scroop is imparted by charging either before or after dyeing with a solution made up of 120 grains of olive-oil soap per gallon of water, to which is added 50 cubic centimeters of 10 per cent. H_2SO_4.

Temperature of this broken soap bath should be about 122° Fahr.

Another beautiful product of chemical industry is the artificial silk made under the patents of Lehner of Zurich and the Compte De Chardonnet, of Bordeaux, which, while not yet of demonstrated practical value on account of high cost of pro-

duction compared to silk and various mechanical defects, yet furnish a valuable starting point for what certainly should be a flourishing industry when these defects are overcome.

If cotton be carefully cleansed and passed through a cold bath of strong nitric acid, it is converted into dinitrocellulose without becoming particularly tender or inflammable.

Pyroxylin or gun cotton of the composition $C_{12}H_{14}(NO_2)6O_{10}$ belongs to the same group of nitrated cellulose compounds, and by means of less concentrated acid we obtain a less nitrated trinitrocellulose known as soluble pyroxylin, which is soluble in alcohol and ether, forming a heavy syrupy fluid known as collodion.

But it is the tetra-nitro cellulose of the same group which forms the basis of the interesting results obtained at different times by Lehner, Chardonnet and others in the artificial silk industry before mentioned.

To produce the remarkable fiber, of which I am able to show typical samples, the pyroxylin, in the form of the tetra-nitrocellulose, is dissolved in a mixture of 38 parts ether and 42 parts alcohol to form a 6·5 per cent. pyroxylin solution.

This solution is introduced into a tinned copper receptacle, from which it is forced by continuous air pressure through a vertical glass tube, ending in a fine capillary orifice, and surrounded by a second glass tube, through which there is a steady flow of cold water.

As soon as the nitrocellulose solution comes in contact with the water it solidifies and may be drawn from the tube as a continuous thread, which, however, is highly inflammable, and must be de-nitrated before it can be safely used.

This is accomplished by first treating with dilute nitric acid, and afterwards with a solution of ammonium phosphate.

The artificial silk thus obtained may now be colored in the same way as ordinary silk, care being taken to avoid boiling, which greatly injures its strength, the temperature of the dye bath being best fixed at or below 180° F.

The greatest faults of this cellulose silk lie in its lack of elasticity and its great loss of strength on becoming wet, to which its hygroscopic nature makes it peculiarly liable.

However, I am informed that the use of 15 per cent. of formaldehyde, acetic aldehyde, paraldehyde or other aldehyde derivatives in the solvent used for the pyroxylin will yield a fiber free from these defects, and that the product of the Chardonnet factories is now so treated.

In this connection it might be added that formaldehyde presents to the textile chemist many very useful characteristics, which are being taken advantage of in several processes now in use, and which we will briefly note.

The product formaldehyde was first obtained by Von Hoffman, in 1867, by passing the vapor of methyl alcohol, mixed with air, over finely-divided Pt heated to redness.

It is also formed in small quantity, together with marsh gas (CH_4) and formic acid $H_2CO_2 = HCOOH$, by the action of silent electric discharges on a mixture of H and CO_2. It may be abundantly obtained at a low cost by the incomplete oxidation of methyl alcohol in a combustion furnace or lamp suitably constructed, and has the formula $CH_2O = HCOH$.

Commercial formaldehyde or formalin is a solution of the gas in water, and has come into great prominence through its wide application as a disinfectant. To the textile chemist the property possessed by formaldehyde of rendering gelatine and other bodies insoluble in water suggests many useful applications in dyeing, color printing and finishing.

Besides its use in adding to the strength and durability of cellulose-artificial silk, it may be used in obtaining a silky fiber of considerable strength by the following method:

Gelatine is dissolved in water and a syrupy solution obtained. Then, by a device somewhat similar to that used in the Chardonnet and Lehner processes, it is drawn out into a thread, which is immediately passed into a 4 per-cent. solution of formaldehyde, which renders the fiber insoluble and capable of being woven or knitted in with other fibers.

In this method the dyestuffs would, however, be better added to the gelatine solution, as, after fixation by formaldehyde, the silky fiber obtained would be very difficultly penetrated by the coloring matter, and unsatisfactory results would follow.

A solution of gelatine, prepared in a dark place, with from ½ to 1 per cent. of bichromate of potash, has also been suggested as a method of obtaining a textile fiber from gelatine, as, owing to the well-known sensitiveness of chrome gelatine to light, it becomes insoluble on exposure, and this derivative has one advantage in being capable of absorbing dyestuffs after fixation. For light colors it is unsuitable, as it always has a dark appearance.

Whether this fiber is destined to hold any practical position in the textile arts is a matter of mere conjecture, as its production so far has not passed beyond the purely experimental stage.

In sizing the backs of velvets and other fabrics, a gelatine solution, colored with any desired dyestuff, is brushed evenly over the surface to be sized, and then the material is either sprayed or brushed over with a 2 per-cent. formaldehyde solution, giving a very permanent and useful size.

In color printing the dyestuffs are added to a gelatine solution of the desired density, and, after the colors are steamed on, the cloth is passed through a 2 per-cent. formaldehyde solution, with the result of fixing the color on the fiber in combination with insoluble gelatine. This reaction has suggested several uses for formaldehyde in printing cotton goods.

In waterproofing it would furnish a uniform coating, which could be cleansed without injury, and capable of being handled very inexpensively. For coating silk or other varieties of fishing lines, it furnishes an enamel which is more permanent and waterproof than any which have so far been used, is entirely without deleterious effect on the fiber, and is already being employed for that purpose, as the samples I have here will testify.

In Lyons, formaldehyde is being extensively experimented with in the manufacture of so-called souple silks, in which the sericine or silk gum is merely softened sufficiently to enable its being handled, and is not boiled off, as is the case with tram and organzine silks.

Formaldehyde has the property of fixing or rendering insoluble this sericine, and is used after the soupling and dyeing

to prevent loss of weight in the different processes to which it is subjected.

There are doubtless other applications in which this insoluble gelatine would be very useful, and another fact, that regarding its property of converting fuchsine and other aniline reds into blues and violets, might not be without hint of possibilities to the colorist.

PHILADELPHIA, March 15, 1898.

IN MEMORIAM.

JULES VIENNOT.

On March 11, 1898, the Franklin Institute lost, by death, a most valued member; one who, though unable to attend its meetings regularly, shrank from no sacrifice of his convenience and from no expenditure of the best that was in him, when the Institute had need of his aid.

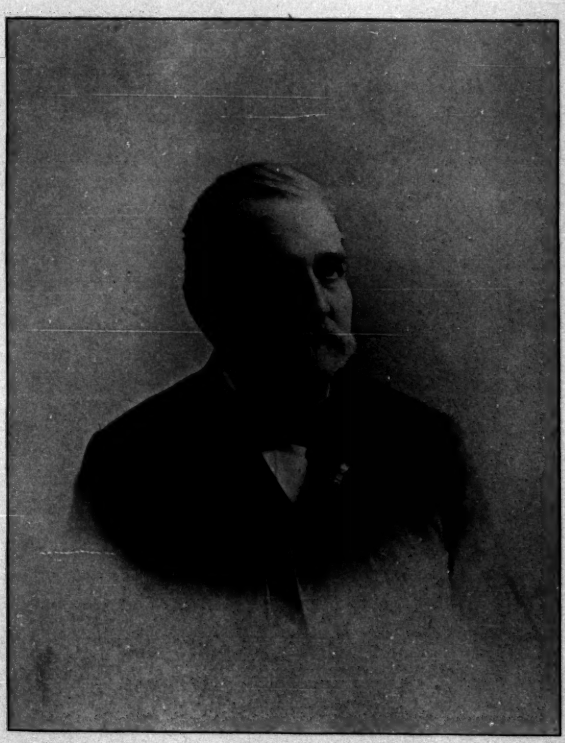
Jules Viennot was born in Paris, in 1825. His father was the owner of "Le Corsaire," one of the leading Parisian political journals of the day.

From 1847 to 1851, the son served in the French army. He was wounded while attacking the barricades of the revolutionists in 1848. After this, and during the "Journées de Juin," he was attached, as instructor, to the Garde Mobile. After leaving the army he was active in commercial life in France and Belgium. In 1853 he was married, in Brussels, and in the early sixties he came, with his wife and daughter, to America, where he has since resided.

In 1880 he settled in Philadelphia, which has ever since been his home. He became a member of the Franklin Institute in 1881. In 1897 he was made a Director of the Société de Bienfaisance Française, of which he had been a member for several years.

Mr. Viennot was especially active in connection with both the Electrical and the Novelties Exhibitions of the Institute, and his untiring activity in securing proper newspaper recognition contributed, in no small degree, to the success of the former of those enterprises.

(*Jour. Frank. Inst., Vol. CXLV., June, 1898.*)



J. Wenner

[1825–1898.]

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In 1894 he received from the French government a decoration in recognition of his hospitable services in behalf of technical and other visitors from France, particularly during the World's Fair in Chicago in 1893, when he devoted himself most unsparingly to the reception and entertainment of a large body of members of the Société des Ingénieurs Civils de France. Members of the Franklin Institute and of the Engineers' Club of Philadelphia will long bear in affectionate remembrance his untiring efforts in behalf of their guests at that time.

During his latter years Mr. Viennot was engaged in building up a prosperous business, in which he represented the advertising interests of his clients, placing their announcements in the various technical and trade papers, advising them in their selection of such journals, and attending to the accounts growing out of those transactions. Such was his zeal and ability in the interests of his clients, that he found himself entrusted with the advertising business of the Baldwin Locomotive Works, the Southwark Foundry and Machine Company, Merchant & Co., and many others of the most prominent engineering and mercantile firms and corporations in Philadelphia and in other cities.

It is easy thus to sketch, in brief outline, what Mr. Viennot was in his outer life; but how impossible to say what he was to his friends. Never was the dread name of "Advertising Agent" more richly graced than by Jules Viennot, gentle man and gentleman, the best conditioned and unwearied spirit in doing courtesies. Combining, in exquisite harmony, all the delicacy of genuine French politeness, with a deep and clear knowledge of affairs, the perfection of modesty, and a rugged, old-fashioned, human thorough-honesty, his personality was a thing apart, and not only won him friends, but endeared him to them as it is the lot of but few to be.

In his kindly smile shone the brightness and warmth, in his delicious broken English sounded the truth and nobility, of the French character. As a compatriot has said, he was one of those Frenchmen who make their country beloved abroad.

For the last time he has brightened our threshold. For the last time he has left us the better for his visit. For the last time he has said—as he was only too ready to say—"And now, I will go. Good-bye." J. C. T., JR.

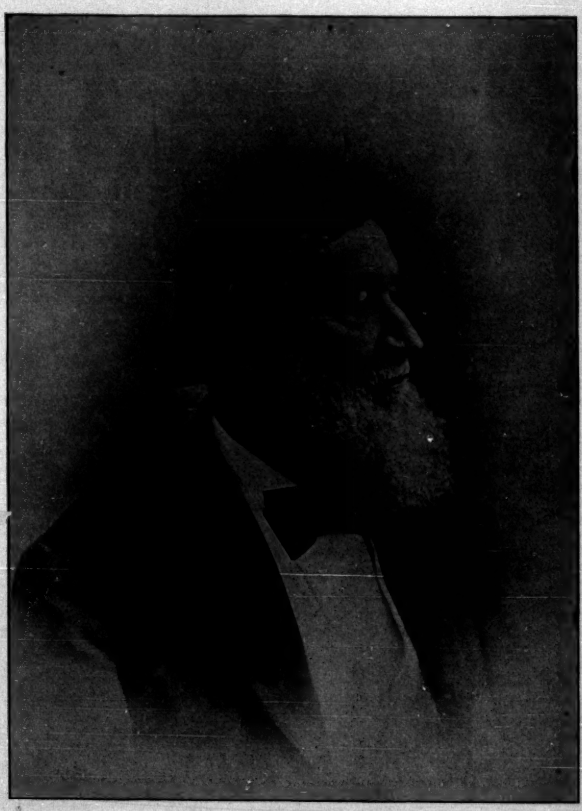
JAMES FOSTER SMITH.

James Foster Smith, of Reading, Pa., one of the oldest civil engineers in the United States, entered into rest on Monday morning, January 31, 1898, in his eighty-fifth year. He sprung from Scotch-Irish ancestry. His grandparents came to America about the year 1783, settling in Pittsburgh; a portion of that early band of Covenanters, the impress of whose sturdy character is still so plainly manifest throughout Western Pennsylvania.

Mr. Smith was born in Pittsburgh, on Christmas Day, 1813. In 1822 his parents moved to Blairsville, Pa., where he received a rudimentary education in the village school; but the necessity of self-support terminated even these meager educational advantages at the early age of twelve years. During such leisure as he was able to spare from daily work he devoted himself to study. His natural inclination carried him into the channels of civil engineering just at the time when the Pennsylvania Canal and other public improvements were in course of construction, and long before a college of engineering was known in America.

In 1831, at the age of eighteen, he entered the service of the Portage Railroad Company as a rodman under the late Solomon W. Roberts. In 1836 he became connected with the Catawissa Railroad as Assistant Engineer under the late Edward Miller, Chief Engineer, but, owing to the financial difficulties of the company, this engagement was of short duration. The years 1837-1838 he spent in the service of the Morris Canal Company as Engineeer-in-Charge, during which time he designed and built, among other works, the tide lock at the outlet of the canal in Jersey City, which is still in use.

Returning, in 1839, to the Catawissa Railroad, he spent the following two years upon that work as principal Assistant



JAMES FOSTER SMITH.
[1813–1898.]

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Engineer. In 1840, he designed the high trestles for which the Catawissa line for years past has been and still is celebrated. The wooden trestles, varying in height from 53 to 129 feet and in length from 600 to 1,100 feet, were the first of the kind in the country. The plans were copied into the leading engineering journals of the day, and copies of the same were also furnished to the engineers of the New York and Erie Railroad, and were adopted by the late Silas Seymour, C.E., as the design of the original Portage Viaduct over the Genesee River. The model of these trestles, which are believed to have been the beginning of high structural works in timber, and essentially the same as now followed in similar constructions of iron and steel, is now standing in the hall of the Franklin Institute. The actual woodwork of this model was made by Mr. Smith, and the bolt work by the late Ellerslie Wallace, M.D., Dean of Jefferson Medical College, then an Assistant Engineer in the Catawissa Railroad. The years 1841-1842, he spent with the New York and Erie Railroad Company as cashier of the Eastern Division, with headquarters at Piermont, N. Y., during which service Mr. Smith originated and put into use the blank forms used in the inward- and outward-bound freight business of the road at that time.

In 1843, Mr. Smith entered the service of the Schuylkill Navigation Company, first as Superintendent of the Lower Division, serving in that capacity, under the presidency of Solomon W. Roberts, until 1845, when the enlargement of the works was put under contract, and Charles Ellet, C.E., having assumed the presidency of the company, he was appointed Resident Engineer, and had charge of the reconstruction of the canal and slack-water navigation between Philadelphia and Reading, completing the same in 1846.

After the disastrous flood of September, 1850, he was elected, by the Board of Managers, Chief Engineer of the company, and proceeded to rebuild the damaged works, making many changes and improvements to defend them against future floods, and to increase their carrying capacity.

He filled the position of Chief Engineer with the Schuylkill Navigation Company under the presidency of Frederick Fraley,

Esq., until 1870, and subsequently with the Philadelphia and Reading Railroad Company until the year 1875 (the Susquehanna and Tidewater Canals having been added to his charge in the meantime), when he relinquished the more active duties of his professional life, but still continued to serve as Consulting Engineer until 1885, when he retired from engineering work.

During the thirty-two years of active service with the Schuylkill Navigation Company, Mr. Smith designed and constructed many important hydraulic works, noticeably most of the existing dams upon the Schuylkill River, built with square back and perpendicular sheet piling instead of the prevailing rafter shape. A type of these structures is the present Fairmount dam at Philadelphia and the great dam, 6,843 feet long, across the Susquehanna River at Columbia. The design has been largely followed in this country and in Europe as being the best to successfully resist floods and the most economical to maintain. Other important works were the extensive shipping landings of the company at Schuylkill Haven and a system of wharves with automatic coal-transferring machinery at Greenwich Point, on the Delaware River, the first of the extensive wharves at that location.

He also constructed extensive aqueducts of stone and wood and many works requiring difficult cofferdamming in such situations as to call for the highest skill of the hydraulic engineer. After his withdrawal from the engineering service of the company, in 1883, Mr. Smith was elected President of the East Pennsylvania Railroad Company, serving for one year, when he retired to private life and the enjoyment of well-earned rest.

Mr. Smith became a member of the Franklin Institute in 1848, and maintained his membership continuously until his death. Although never conspicuously active, he manifested much interest in the work of the Institute, and was a frequent attendant at its meetings. He contributed to its *Journal* a valuable paper on "The Future Water Supply of the City of Philadelphia" (*vide Jour. Frank. Inst.*, vol. cviii, 236, *et seq.*), in which he ably advocated the proposition for a gravity supply by aqueduct from the Perkiomen.

In the death of the subject of this sketch the engineering profession and the Franklin Institute lose a valued member and the community a useful citizen. W.

ERRATUM.

ART.: CREHORE AND SQUIER SYNCHRONOGRAPH. DISCUSSION.

In Mr. Delany's contribution, May impression, page 371, 12th line, after the word . . . periods, it should read:

"And signals may be recorded at a higher speed provided the tapes of ordinary telegraphic use can be made as synchronous with the generator as permanently fastened pieces of paper mounted with mathematical precision on a circuit wheel, but so far as chemical recording is concerned, even with this arrangement and the utterly impracticable character of received signals, there can be no increase of speed."

CORRESPONDENCE.

A WARM WINTER.

The Committee on Publications:

GENTLEMEN:—It is evident that we have passed through an unusually warm season, and it is reasonable to inquire how much the temperature has varied from that of an average winter. The Weather Bureau follows the business man's method by making comparisons between the records for calendar periods. The seasons, however, do not correspond to months or years, and, in fact, are so indefinite when mentioned in prose or poetry, that the days of their beginning or ending cannot be stated. Hence there is no such record as that of a season's temperature, though to people generally the subject is one of much interest and speculation.

In our latitude the seasonal or normal movement of temperature lags behind the sun's apparent motion north and south of the equator, the extremes not being reached until about the 22d of January and July, or in each case about one month after the solstice, while midway between the extremes the normal temperature of the day crosses the normal of the year about one month after the equinoxes. These dates of crossing may well be called the equi-normal dates, and mark the divisions of the warm and cold halves of the temperature year.

It is proposed to give a measurement of these definite temperature periods from the U. S. Weather Bureau's local weather reports, so familiar to the readers of the daily newspapers. Extracts from reports for two equi-normal dates are given below:

U.S. WEATHER BUREAU, Philadelphia, Pa., Friday, October 22, 1897.				U.S. WEATHER BUREAU, Philadelphia, Pa., Friday, April 22, 1898.			
Max. tem. (2.00 P.M.)	54	Min. tem. (Mid., 22-23)	48	Max. tem. (1.00 P.M.)	65	Min. tem. (5 00 A.M.)	45
Mean temp	51	Normal temp	54	Mean temp.	55	Normal temp. . . .	54
Deficiency of temperature to day, 3.				Excess of temperature to-day, 1.			
Excess of temp. since Oct. 1, 70.				Accumulated defic'y of temp. since April 1, 11.			
Accumulated excess of temp. since Jan. 1, 248.				Accumulated excess of temp. since Jan. 1, 424.			

It will be seen that the sum of the maximum and minimum temperatures divided by two is taken as the mean of the day. The average of the daily means for all the days of any particular date, since the station was established is considered as the normal of that day. For the days selected, the normals were 54°, or the same as the normal of the whole year. The difference between the mean and normal is the excess or deficiency of temperature, and the net accumulations of these differences since the first day of the year and the first day of the month, are stated in the reports.

On the 22d of April, 1897, the accumulation of excesses was 126°, and by the 22d of October, 1897, the excesses had accumulated, as shown by the report, to 249°, so that the accumulation for the warm half-year between these dates was 123°. By the 31st of December there was a further accumulation of 148°, and, this added to the 424° accumu'ated since the 1st of January, as appears in the report of April 22, 1898, gives a sum of 572° for the accumulation of warmth for the cold-half of the year.

If we divide the total for the half year by 182, the number of days in the period, we find that there was an average daily excess of 3¼ degrees. The further character of this winter half-year is shown by the figures for first quarter to January 22d, when the accumulation of excess was 255°, while after that date there was a further accumulation of 317°. The greatest accumulation was reached March 30th, when the total excess was 584°.

If readers will have in mind that the accumulation of excesses on April 22d was 424°, they can easily reckon from the daily reports, the progress of the summer half-year, and by taking bearings again on October 22d the progress of next winter's half-year may also be noted from day to day. In this latitude the winter half-years are of special interest to housekeepers, for they correspond closely with periods for heater fires.

In the table below comparison is made between the accumulated temperatures of the half-years for eleven years.

Warm Half-Year, from April 23 to Oct. 22, inclusive.	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897
Accumulated excess of temperature	159			93	27	109		177	139	112	123
Accumulated deficiency of temperature		353	26				11				

Cold Half-Year, from Oct. 23 to April 22, inclusive.	1887–8	1888–9	1889–90	1890–1	1891–2	1892–3	1893–4	1894–5	1895–6	1896–7	1897–8
Accumulated excess of temperature		396	951	234			292		125	287	572
Accumulated deficiency of temperature	127				17	442		338			

As a further standard of comparison, it may be stated that the winter of 1889–90 was much the warmest of any shown by the Philadelphia records for seventy-two years past.

Respectfully,

HENRY GAWTHROP.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, May 18, 1898.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 18, 1898.

The President, MR. JOHN BIRKINBINE, in the chair.

Present, 210 members and visitors.

Additions to membership since last report, 5.

Mr. Wm. F. Roberts supplemented his communication of last month, on the carbon dioxide engine, by a description of a condensing engine of the same type. An exhibition of the operation of this apparatus, which had been contemplated, was deferred until the June meeting.

Mr. W. S. Ryan, of the Philadelphia Museums, made an extemporaneous address on the Philippine Islands, giving some account of the Islands, their inhabitants, and the administration of the group by the government of Spain. Prof. Wm. P. Wilson, Director of the Museums, supplemented these remarks with an account of the productions of the Islands, and statistics of their trade and commerce.

Mr. E. D. Meier, engineer-in-chief of the Diesel Motor Company, New York, read a paper on the Diesel Motor, illustrating the subject with the aid diagrams. (Referred for publication.) The subject was referred, for investigation and report, to the Committee on Science and the Arts.

Adjourned.

WM. H. WAHL, *Secretary.*

COMMITTEE ON SCIENCE AND THE ARTS.

[*Abstract of proceedings of the stated meeting held Wednesday, May 4, 1898.*]

PROF. L. F. RONDINELLA in the chair.

Reports on the following subjects were considered:

Severy Impression Process.—Melvin L. Severy, Boston, Mass. Passed first reading.

Hard-drawn Copper Wire.—Thos. B. Doolittle, Branford, Conn. Passed first reading.

Improvements in X-ray Tubes.—H. Lyman Sayen, Philadelphia, Pa. Passed first reading.

System of Aërial Navigation—H. H. Fisher, Corpus Christi, Tex. Passed first reading.

Pneumatic Balance Lock.—Chauncey N. Dutton, New York. Passed first reading.

Compound Locomotive.—Clifton L. Reeves, Trenton, N. J. On the strength of a protest from applicant, this subject was reconsidered, and the report and and protest were referred to a new sub committee.

The following reports were adopted:

Improvements in Turnbuckles.—E. W. Merrill, Brooklyn, N. Y.

ABSTRACT.—The claims of applicant are based on a patented procedure (see U. S. Letters-patent No. 462,499, November 3, 1891), which consists in rolling the general shape of the turnbuckle from a bar of steel in suitably shaped rolls. This operation leaves a fin in the centre between the shanks, which is subsequently punched out. By a third operation, the bosses are swaged up in order to bring up the inner edges of the bosses, which had a rounded contour after the rolling operation. This third operation, upon which the applicant lays special stress, is held in the report to be quite useless, as the extra metal thereby incorporated in the turnbuckle neither adds to its strength nor improves its form.

The report concludes with the statement that the operations described in the patented process of applicant present no specially novel or valuable features. [*Sub-Committee.*—A. Falkenau, Chairman; Wilfred Lewis.]

Swivel-Loom.—Herman Willmunder, Philadelphia.

ABSTRACT.—This invention is an attachment to a loom adapted to the purpose of weaving into the fabric small figures (such as flowers), without carrying the material of which they are made entirely across the fabric, and without using warp threads for the figures. Such an arrangement is known in the art as a "swivel-loom."

The report makes reference to previous attempts to weave shaded figures on the face of cloth, which was done formerly by the use of hand-looms, requiring the most skilled weavers, and more recently on power-looms by the Jacquard mechanism. The report concludes that this inventor has considerably improved and simplified this last-named device for accomplishing the purpose intended. An intelligible description of the attachment in detail is not possible without the aid of illustrations. The Scott award is recommended. [*Sub-Committee.*—G. Morgan Eldridge, Chairman; John Shinn, Robert B. Goodyear.]

Abatement of the Smoke Nuisance.—Referred by the Institute.

ABSTRACT.—The Committee recommends certain conclusions to be recommended to the Board of Managers for embodiment in the draft of an ordinance to be transmitted to the Bureau of Health. [*Sub-Committee.*—H. W. Spangler, Chairman; Wm. M. Barr, John Birkinbine, Alex. E. Outerbridge, Jr., Coleman Sellers.]

Ejector for Fluids.—W. B. Hollingshead, Bronxville, N. Y.

ABSTRACT.—This invention has been previously described in these abstracts (see the *Journal*, cxliii, 454), to which reference is made.

The present report is the outcome of a reconsideration of the case on an appeal by applicant, and revises the conclusions of the previous one.

It is found, by practical tests for a period of three months, under the unfavorable conditions of using unfiltered Schuylkill water, that the device was demonstrated to be reliable.

As an inexpensive and easily-cared-for apparatus for the automatic distribution of disinfecting materials soluble in water, the device is approved. The Edward Longstreth Medal of Merit is awarded. [*Sub-Committee*, H. R. Heyl, Chairman; John G. Bullock.]

Arrangement of Cylinders for Balanced Locomotives.—J. H. Dunbar, Youngstown, Pa.

ABSTRACT.—This device is an arrangement of two cylinders in tandem on each side of a locomotive, for the purpose of counterbalancing the reciprocating parts without weights in the driving-wheels. It consists of a cylinder, located as usual on each side of the engine, with its piston-rod, crosshead, and connecting-rod connecting to the crank-pins. In addition, another cylinder is placed directly in front of the first cylinder, with its piston-rod connected with one end of a lever arm, or walking-beam, pivoted at or near its centre, in a support or bracket in front of or below this cylinder, the opposite or lower end of the walking-beam being connected by a rod extending backward to the crosshead of the first cylinder.

By this arrangement, the applicant claims that the momentum of the reciprocating parts is equalized by the moving of the pistons in opposite directions.

The committee fails to discover this result, but finds that the additional parts would increase the amount of counterbalance needed in the driving-wheels, and, furthermore, that the mechanical arrangement as set forth is such as to be impracticable for locomotive use. [*Sub-Committee.*—J. Logan Fitts, Chairman; Henry F. Colvin, Arthur J. Rowland.]

Check-Funch.—G. O. Brosnaham, Pensacola, Fla.

ABSTRACT.—The work of this punch consists in making a printed impression of the figures and symbols in the form of a series of dots, resembling those actually punched out of the paper (by actual perforation) in the machines formerly in common use by the United States Government and by financial institutions generally.

Those machines which perforate the paper by means of round holes, however, have practically been discarded for those in which the perforation of the paper includes the general outline of the figures and symbols. In this form of perforation there appears to be no serious danger that the figures or symbols can be fraudulently altered without detection.

A machine that simply prints what we generally write, the investigating committee believes, does not present, in this case, any advantage, while the cutting out of the paper is an extra safeguard against fraud; also, the machine of applicant is more costly and complex than those in use producing practically the same result. [*Sub-Committee.*—Edward F. Moody, Chairman.]

SECTIONS.

ELECTRICAL SECTION.—*Special Meeting* held Tuesday, March 29. 1898. Present 50 members and visitors. Mr. W. E. Harrington, President, in the chair. A paper on "The Substitution of Electricity for Steam on Suburban Roads," which had been announced as the special business of the meeting, was postponed at the request of Dr. Louis Duncan, the author.

The meeting thereupon engaged in an impromptu discussion of the subject of Rail-bonding, which was participated in by Messrs. Pepper, Reed, Hering, Brogg, and Harrington.

The drift of opinion was to the effect that the commercial forms of bonds making contacts through holes in the web of the rails were impractical and the form of bond consisting of copper-plates making contact with the sides of the web of the rail and using flexible solder or other metallic connection appeared to be the best adapted, mechanically and electrically, for the intended service.

WM. WARR, *Secretary.*

MINING AND METALLURGICAL SECTION.—*Stated Meeting* Wednesday, May 11, 1898, Mr. A. E. Outerbridge, Jr., in the chair. Present 29 members and visitors. Mr. William Tatham presented a paper on "Gold Mining in Georgia," giving a brief sketch of the character and extent of the gold-bearing deposits and of their past and present development, the proper methods of treating the ores, etc. Discussed by Messrs. Outerbridge, Garrison, Wahl, and the author. (Referred for publication.)

Mr. Guillaum H. Clamer read a paper entitled "On the Micro Structure of Bearing Metals." The subject was very thoroughly treated, and embodied the results of numerous original observations The paper was illustrated by means of lantern projections of photographic enlargements of numerous typical specimens of micro photographs. The paper evoked an animated discussion, participated in by Messrs. Christie, de Benneville, Outerbridge and the author. (Referred for publication.) Adjourned.

JAMES B. DE BENNEVILLE, *Secretary.*

CHEMICAL SECTION.—Stated meeting held Tuesday, May 17, 1897, President, Lee K. Frankel, in the chair.

Dr. Harry F. Keller presented a preliminary communication on "The Synthetic Preparation of the Hydroxy-acids." Discussed by Dr. W. C. Day, Mr. C. J. Reed, and the author.

Dr. Wm. C. Day made an informal communication on the artificial preparation of an asphaltum-like substance, possessing substantially the same composition as gilsonite, and analogous physical properties. The method followed consisted in subjecting to destructive distillation a mixture of fish and resinous pine chips, and passing the distillate through a red-hot iron tube. Discussed by Mr. Jos. Richards, Mr. C. J. Reed, and the author.

Adjourned.

LYMAN F. KEBLER, *Secretary.*